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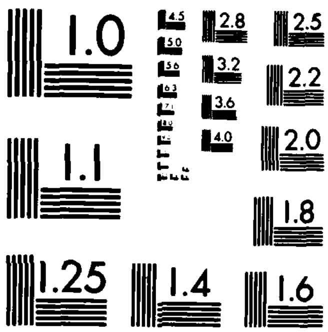
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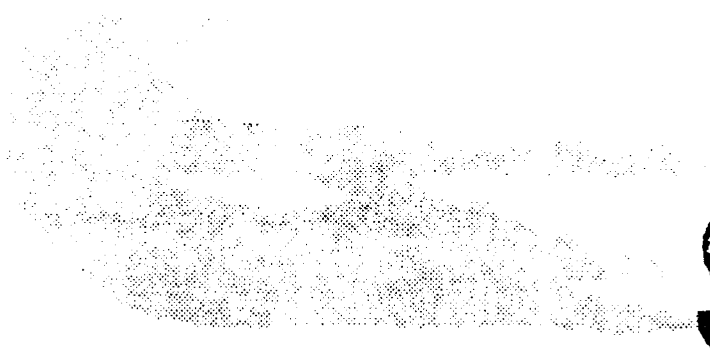
GREAT I

SEDIMENT AND EROSION



WORK GROUP APPENDIX

UPPER MISSISSIPPI RIVER
(HEAD OF NAVIGATION TO GUTTENBERG, IOWA)

SEPTEMBER 1979
GREAT RIVER ENVIRONMENTAL ACTION TEAM

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The Sediment and Erosion Work Group has demonstrated that sediment from upland and streambank erosion poses an immediate and serious threat to the vital environmental resources of the Mississippi River corridor. The nature and extent of the sediment problem has been determined; and solutions studies, and target areas identified.

Widespread sedimentation wil only be remedied by controlling erosion from upland areas under agricultural use, and diking and shoreline protection can

be used at strategic locations to help prevent further decline of habitat by preventing fine sediments from accumulating.

This copy of the GREAT I Sedement and Erosion Work Group report does not contain all of the maps. To obtain copies of the maps, please contact:

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SEDIMENT AND EROSION WORK GROUP APPENDIX

TO

GREAT RIVER ENVIRONMENTAL ACTION TEAM I FINAL REPORT

Chairmen - U.S. Department of Agriculture -
Soil Conservation Service

Gary S. LePage 1978-79

Chester A. Weldon 1975-78

Herman H. Calhoun 1975

In fulfillment of contract with the
U.S. Army Corps of Engineers
St. Paul District

FOREWORD FROM THE GREAT TEAM

This report was prepared by the Sediment and Erosion Work Group of the Great River Environmental Action Team (GREAT I). The conclusions and recommendations presented reflect the work performed by this work group only, within its specific area of expertise. Recommendations from this report will be considered in relation to other objectives for overall resource management and may be included in the final GREAT I report as considered appropriate by the GREAT I Team.

EXECUTIVE SUMMARY

Lake Pepin and the backwaters of the Mississippi River are truly one of the great environmental, recreation, and economic resources of North America. In addition to being the home for tens of thousands of species of plants and animals, the Mississippi flyway is a vital link in the life cycle of approximately three-fourths of the Nation's migratory waterfowl. Without the feeding and resting areas provided by the Mississippi River and its backwaters, many of these birds would perish.

The Sediment and Erosion Work Group has demonstrated that sediment from upland and streambank erosion poses an immediate and serious threat to the vital environmental resources of the river corridor. The work group has determined the nature and extent of the sediment problem. Solutions have been studied and the target area for action has been identified.

The work group has shown that:

1. The life expectancy of the backwater areas is limited if present rates of sedimentation are allowed to continue. Already, approximately one-quarter of the open water area present when the lock and dam system was completed has become marshland.

2. From 1895 to the present, approximately one-third of the capacity of Lake Pepin has been lost to sediment. Some areas of the lake which were once 8 to 12 feet deep are now 2 to 4 feet deep. A unique recreation and environmental resource is dying.

3. The primary source of the fine sediments which are clogging the backwaters and filling Lake Pepin is erosion from farmlands. The principal source area is relatively small - approximately 9 million acres out of a total of 51 million acres in the total drainage area.

4. The primary source of the sand which fills the main channel is streambank erosion from tributaries. The majority of this sand comes from key sand producing tributaries. These tributaries have been identified. The greatest contributor of sand is the Chippewa River in Wisconsin. Accumulating sand sediments ultimately must be dredged to maintain the 9-foot channel. Disposal of this dredged material must be done in an environmentally sensitive manner to minimize further habitat destruction.

5. Erosion control alternatives available under existing programs and technology could reduce upland erosion by one-third in the fine sediment source areas. Such a program would cost an estimated $243 million initially and $44 million to maintain. Because existing treatment measures are able to reduce erosion only by one-third, new, more intensive erosion control practices need to be identified.

6. Preliminary feasibility studies indicate that streambank stabilization measures may reduce coarse sedimentation at some locations.

On the basis of these findings, the Sediment and Erosion Work Group recommends the following comprehensive program:

1. <u>Accelerated Upland Land Treatment</u>. - Existing land treatment programs should be funded to achieve the maximum erosion control possible. A goal of 80-percent land adequately protected by Soil Conservation Service standards should be established.

2. <u>Conservation Tillage Farming</u>. - New technology in erosion control should be investigated to refine the techniques for application in the sediment source area. A demonstration watershed should be selected and monitored to determine the potential for erosion reduction. New erosion control practices are absolutely essential to any plan designed to preserve the backwaters.

3. Chippewa River Study. - Preliminary work on the Chippewa River has identified a number of potentially workable streambank erosion measures. This work should be continued.

4. Shoreline Protection. - The Corps of Engineers should continue its program of installing shoreline protection in the main river corridor. The Sediment and Erosion Work Group has worked with other work groups to prepare a priority list for these shoreline protection measures.

5. Streambank Protection. - The Corps of Engineers and the Soil Conservation Service should examine the potential for streambank protection measures on all tributaries of the Mississippi River.

6. Dredged Material Stabilization. - All dredged material piles should be stabilized with vegetation to prevent secondary movement.

7. Sediment Monitoring. - U.S. Geological Survey sediment monitoring stations should continue, and priorities should be set for establishing additional monitoring stations. Data supplied by these stations would be useful in determining priorities for erosion control.

8. Diking of Backwaters. - Diking off wildlife areas from the main channel should be considered as a possibility for protection from sediment damage. Diking should be done only after consideration of all the environmental and hydrological consequences.

Time is the most important ingredient in any plan designed to deal with sedimentation in the Mississippi River. The river environment is deteriorating rapidly. Action to reverse this deterioration must be started immediately, or this part of the river, which is so important to wildlife and recreationists alike, will continue to die.

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CHAPTER I

INTRODUCTION

The Mississippi River is the largest river system in North America, gathering runoff from 31 States and 2 Canadian Provinces and draining 1.5 million square miles. On one hand, the river is a road for the transportation of agricultural products from the grain belt of the Midwest to the seaports of the South and a conduit for the fuel supplies which heat northern cities and fuel our industries. On the other hand, it is the largest environmental corridor in North America. Over 500 kinds of animals live among the diverse plant communities that thrive in and along the river.

Maintenance of the 9-foot navigation channel has required periodic dredging and disposal of bottom sediments. The accumulation of these sediments results from natural movement within the main channel, depositions at the mouth of tributary channels, and the movement of previously dredged materials. In most cases, the material dredged from the river channel has been deposited in the shallow backwater areas out of the main channel, on natural islands, or on newly created islands immediately adjacent to the channel. The disposal of dredged material has affected the valuable acreages of productive fish and wildlife habitat.

The people of the Upper Mississippi River valley have become increasingly concerned that the river be managed for the development of all of the river resources including fish and wildlife, navigation, recreation, and water quality. GREAT (the Great River Environmental Action Team), operating under the auspices of the UMRBC (Upper Mississippi River Basin Commission), was formed to represent the interests of the region in carrying out this study which will result in a plan that will provide for a balanced use of the river's resources.

GREAT

GREAT was formed in 1974 to establish a long-range management strategy for the multipurpose use of the Upper Mississippi River. The team includes representatives from the States of Iowa, Minnesota, and Wisconsin; the U.S. Department of the Interior - Fish and Wildlife Service; the U.S. Department of Agriculture - Soil Conservation Service; the U.S. Army Corps of Engineers - St. Paul District; the U.S. Department of Transportation; and the U.S. Environmental Protection Agency.

The GREAT I study area includes the head of navigation at Minneapolis/St. Paul, Minnesota, to lock and dam 10 at Guttenberg, Iowa. As Congress authorized in the 1976 Water Resources Development Act, the Great River Study was directed to investigate and study the development of a river system management plan incorporating total river resource requirements including, but not limited to, navigation, the effects of increased barge traffic, fish and wildlife, recreation, watershed management, and water quality. The organization of GREAT I includes overseeing committees and commissions which provide guidance, direction, and advice to GREAT I. Eleven functional work groups were organized to accomplish specific study objectives.

SEDIMENT AND EROSION WORK GROUP

One of the major problems identified by GREAT is the continuing sedimentation of the main channel and associated backwater areas of the river. Ironically, the lock and dam system which created many of the backwater areas also has contributed to the sedimentation process. The impoundment of the river has reduced its ability to transport sediment through the natural "flushing" process which occurs during floods and high flows. The result is:

1. A navigation channel that requires periodic dredging and disposal to maintain depth for towboats.

2. Accumulation of sediments throughout the river corridor.

The SEWG (Sediment and Erosion Work Group) was formed to study the overall sedimentation problem in the river system.

The following table summarizes the planning process the work group used to study the problem of sediment and erosion in the GREAT I area. The work group coordinated its study efforts with other GREAT work groups to avoid duplication of effort. The chapters which follow point out the severity of the erosion and sedimentation problem in the Upper Mississippi River and are the basis for the work group's conclusions and recommendations for action to resolve sediment related problems.

Sediment and Erosion Work Gr[illegible]

Need for the study	Objectives of the work group	Problems identified by the work group
Channel maintenance is damaging the river environment.	1. Develop ways to reduce dredging. 2. Develop measures to preserve and enhance the environmental values of the river.	1. Streambank erosion of tributaries increases dredging requirements. 2. Secondary movement of dredged material affects backwaters and dredging requirements. 3. Fine sediment from upland erosion affects backwaters. 4. Lake Pepin is rapidly filling in as a result of sedimentation and dredging. 5. Backwaters and side channels are filling in and impairing recreational access. 6. Increased sedimentation is increasing flood elevations. 7. Accelerated sedimentation is shortening pool life. 8. Aquatic habitat is being lost as a result of sedimentation.

...sion Work Group planning process

Work group objectives	Work group alternatives not addressed	Work group projects	[illegible]
1. Identify sources of sedimentation (problems 1, 3, 4, 5, 7, 8).	1. Status quo (do nothing) - would subject resource to irreversible damage in a relatively short time (50- to 250-year life expectancy of backwaters).	1. Prepare sediment source maps (objectives 1, 2, 8, 10).	1. [illegible] time a[illegible] sources identi[illegible]
2. Determine sediment contributions from tributaries (problems 1, 3, 4, 5, 7, 8).	2. Establish complete (one-quarter mile) cross section data - cost constraints.	2. Establish tributary monitoring stations (objectives [illegible], 2, 8).	2. Backwaters and [illegible] [illegible] less [illegible] (projects 3, 4[illegible]
3. Monitor rates of sedimentation and erosion within the river corridor (problem 2).	3. Nonpoint sediment pollution control demonstration project - beyond scope of GREAT, cost is prohibitive.	3. Monitor sediment rates in backwaters and Lake Pepin using cesium 137, fathometer, spud survey, and cross-section comparisons (objectives 4, 5, 8).	3. Streambank eros[illegible] of dredging re[illegible] 2, 5, 7).
4. Determine sediment rate at Lake Pepin and need for abatement (problem 4).	4. Determine sediment yield from dredged material disposal areas - quantity is relatively small with respect to total sediment yield.	4. Prepare vegetative inventory maps to show loss of aquatic habitat (objectives 1, 2, 3, 5, 6).	4. Aquatic habitat [illegible] sedimentation [illegible]
5. Determine sediment rate in backwaters (problems 3, 4, 5, 7, 8).		5. Evaluate and assign priorities to the main channel border for shoreline protection (objectives 1, 3, 4, 5, 8).	5. Side channels a[illegible] being cut off b[illegible] of dredged mat[illegible]
6. Determine critical sources and costs and methods for upland treatment (problems 3, 4, 7, 8).		6. Research and evaluate erosion and land treatment alternatives (objectives 6, 7, 8, 9).	6. Upland erosion [illegible] fine sediments [illegible] 6).
7. Determine methods and costs for streambank protection (problem 1).		7. Review progress of Chippewa River demonstration project (objectives 1, 2, 7, 8, 9).	7. Erosion contro[illegible] bank and upland[illegible] to implement (p[illegible]
8. Evaluate alternatives to reduce sedimentation in the river corridor (problems 1, 2, 3, 4, 5, 6, 7, 8).			8. Existing erosion [illegible] control measure[illegible] resolving sedim[illegible] [illegible]
9. Inventory and research existing data.			
10. Prepare maps and illustrations as work group aids.			
11. Draft SEWG appendix.			

projects	Project results	Work group conclusions	Recommendations
rce maps (objectives	1. Critical fine and coarse sediment sources identified (projects 1, 2).	1. Increased control practices (upland and streambank) must be used on critical source areas.	1. Accelerate existing upland erosion control practices.
monitoring stations).	2. Backwaters and Lake Pepin will fill in unless sedimentation is reduced (projects 3, 4).	2. New control alternatives (especially no-till) must be examined to determine feasibility.	2. Determine feasibility of no-till and other upland control. Conduct demonstration project at an identified critical source to monitor results.
les in backwaters and sium 137, fathometer, oss-section compari- , 5, 8).	3. Streambank erosion is a major cause of dredging required (projects 1, 2, 5, 7).	3. Monitoring of critical source sediment must be continued and expanded to establish base-line data, identify critical areas, and determine results of implementation.	3. Continue to evaluate streambank protection alternatives.
nventory maps to show bitat (objectives 1, 2,	4. Aquatic habitat is being lost to sedimentation (project 4).	4. River corridor projects must be continued or created to reduce the impacts of sedimentation on backwaters.	4. Continue Corps shoreline protection.
priorities to the main shoreline protection 4, 5, 8).	5. Side channels and backwaters are being cut off by secondary movement of dredged material (projects 3, 4, 5).	5. Funding sources and authority for implementing control measures must be identified.	5. Follow up on streambank erosion inventory to identify and classify sites not inventoried.
re erosion and land ives (objectives	6. Upland erosion is major source of fine sediments (projects 1, 2, 3, 4, 6).		6. Stabilize dredged material disposal sites.
ippewa River demon- objectives 1, 2, 3,	7. Erosion control alternatives (streambank and upland) are very expensive to implement (projects 6 and 7).		7. Continue and expand tributary monitoring program.
	8. Existing erosion (streambank and upland) control measures are not capable of resolving sedimentation problem (project 6).		8. Consider diking as an alternative to protect critical backwaters.

CHAPTER II

SEDIMENTATION RATES IN POOLS 4 THROUGH 10 AND SELECTED BACKWATERS

INTRODUCTION

The work group used several methods to determine the rate of sedimentation in the pools and backwaters. A series of contracts were awarded to obtain general information on the amount and extent of sedimentation in the river corridor. The results were then evaluated and used to determine the rate of sedimentation. This chapter will explain how Cs-137 (Cesium-137 - a radioactive isotyope) and spud and fathometer surveys were used to determine sedimentation rates in Mississippi River pools 4 through 10 (below Lake Pepin to Guttenberg) and their backwaters. Additional sections discuss the sedimentation rate in Lake Pepin (Chapter III) and recent (1939-1973) loss of aquatic habitat from sedimentation in pools 5 through 10 (Chapter V).

CS-137 SEDIMENT DATING TECHNIQUE

The work group contracted with the SEA (Science and Education Administration) Sedimentation Lab, Oxford, Mississippi, to determine the amounts and rates of sediment deposition in pools 4 through 10. SEA used the Cs-137 technique it developed.

The following abstract (McHenry and Ritchie, 1975) explains the concept of the dating method. In-depth information can be found in: (1) McHenry, Ritchie, and Gill, 1963; and (2) Ritchie and McHenry, 1973.

Radioisotopes have been introduced into the atmosphere by nuclear bomb test explosions. Wind and water have distributed this fallout over the earth's surface, tagging the surface soil with identifiable and unique tracers.

Cs-137 is of special interest because of its abundance and properties. It is strongly absorbed by the finer soil particles, inorganic or organic. In addition, it has an energetic gamma emission which makes it easier to detect and quantify. Thus, when attached to fine soil particles, Cs-137 facilitates the tracing of those labeled soil particles in the sedimentation process.

If the fallout Cs-137 is deposited uniformly over a watershed, both surface soils and existing surface sediments should receive equal amounts of fallout. If erosion occurs, some Cs-137 labeled soil particles will be removed and deposited downstream as sediment. If this is a frequent process during the years when Cs-137 fallout is large, the resulting sediment will be labeled with Cs-137. Where soils are actively eroding, little or no Cs-137 will remain and, as the fallout rate decreases, the annual erosion will contain a lesser amount of Cs-137 labeled particles. Thus, the accumulating sediment profile should reflect the yearly intensity of fallout on the watershed.

The peak radioactive fallout years were 1962-1964 when the Russians conducted nuclear tests. A smaller, definable fallout peak occurred in 1957-1959 as a result of American tests. Since 1963, the Cs-137 fallout rate has steadily decreased, except for a very minor increase after 1971 resulting from Chinese and French testing. If the accumulating sediment profile is undisturbed and sediment inflow is regular, the profile will exhibit a large peak concentration corresponding to the 1962-1964 fallout and a secondary peak for the earlier 1957-1959 period. Cs-137 in a sediment profile indicates the sediment was deposited since 1954; a sharp peak concentration indicates that sediment was deposited in 1963-1964. Thus, the age and rate of recent sedimentation can be estimated.

STUDY DESCRIPTION

In 1975, the SEA started to sample sediments in pools 4 through 10 to obtain general sedimentation rate information. Because Cs-137 is strongly attached only to fine sediments, sampling sites were selected in those areas where fine sediments are deposited (typically the backwaters and lower reaches of each pool). Samples were taken by spud survey from 47 locations scattered throughout the study area (McHenry and Ritchie, 1975).

In 1976-1977, the work group contracted with SEA to conduct follow-up extensive sedimentation rate studies for pools 7, 8, and 9. In addition to Cs-137 surveys, pools 8 and 9 were measured with a recording fathometer to determine bottom contours along established cross sections. Pool 7 (Lake Onalaska) contour data were already available (Claflin, 1977). Fathometer results were plotted and compared with 1937 preclosure contour maps to detect postimpoundment sediment accumulations.

The fathometer and spud surveys were useful for computing recent sedimentation. The spud survey produced a sediment core sample that could be analyzed on the basis of sediment consolidation. Recently accumulated layers of sediment (postimpoundment) would have the least density. The spud survey could, therefore, help reveal the amount of sediment deposited since impoundment.

By comparing the results of the Cs-137, spud, and fathometer surveys, a representative sedimentation rate could be calculated. Because sampling or surveys were site selective and widely dispersed over the study area, the accumulated amount of sediment is an estimate. A general conclusion, however, can be reached on the amount and extent of sedimentation.

Because Cs-137 tracing depends on presence of fine sediment, sieve analysis testing was performed on all samples taken to determine if fine sediments were present. This was particularly important in the recent layers of sediment where the tracer isotope is expected to be present. Particle size data were also useful for determining the source of sediment (that is, product of upland or streambank erosion).

The sedimentation rate is indicative of only fine particle accumulation which takes place in lower current velocities normally found in the backwaters or lower reaches of each pool. The source of these sediments is primarily upland erosion. Deposition of coarse sediment (sand) is a separate problem on the river because of its primary source (streambank erosion) and because transport of sand sediment is usually confined to within the main channel or main channel border. Erosion and deposition of coarse sediment is further discussed in Chapter IV.

STUDY RESULTS

Although a large number of data have been collected, tabulated, and illustrated regarding the amount of accumulated sediments deposited in backwaters and low-flow pool areas, the most important product of the studies described in this chapter is the estimate of sedimentation rates. The following tables and narrative summarize that information.

Calculated sediment accumulation rates, pools 4 through 10[1]

Pool	Maximum depth of Cs-137 deposition (centimeters)	Estimated rate of sedimentation (centimeters per year)	
		Since 1955	1963-1975
4	50	2.5	2.5
6	70	3.5	4.2
8	60	3.0	4.2
9	70	3.5	3.3
10	70	3.5	4.2

(1) From McHenry, Ritchie, and Verdon, 1976.

Sediment accumulation rates in pool 7[1]

Area	Number of profiles	Average annual sediment accumulation rates (centimeters per year) 1954-1977[2]	1938-1976[3]
1	0	-	0.7
2	2	2.15	1.0
3	2	1.75	2.7
4	2	1.10	1.5
5	2	1.55	2.3
6	4	1.72	1.7
7	3	1.90	1.6
8	3	2.47	1.6

(1) From McHenry and Ritchie, 1978.
(2) Using Cs-137 method.
(3) From Claflin, 1977.

Sediment accumulation rates in pool 8[1]

Cross section	River mile	Average annual sedimentation rate (centimeters per year) Fathometer (1937-1977)	Spud (1937-1977)	Cs-137 1957-1964	Cs-137 1964-1977	Cs-137 1954-1977
1	681.8	0.60	1.28	1.33	2.05	1.74
2	682.8	1.14	1.30	1.00	1.28	1.01
3	684.0	0.24	1.84	2.00	3.07	2.61
4	685.4	0.72	0.74	1.00	1.54	1.30
5	686.9	0.62	1.07	2.33	2.82	2.61
6	688.4	0.50	0.88	1.67	2.31	2.03
Average	-	0.64	1.18	1.56	2.18	1.88

(1) From McHenry, Ritchie, and Cooper, 1978.

Sediment accumulation rates in pool 9 (1)

Cross section	River mile	Average annual sedimentation rate (centimeters per year)					
		Fathometer (1937-1976)		Spud (1937-1976)	Cs-137		
		500-foot (2)	Planimeter (3)		1954-1964	1964-1976	1954-1976
1	648.7	0.5	0.5	1.4	1.0	1.9	1.5
2	649.4	0.4	0.4	1.1	1.0	2.7	2.0
3	651.1	0.8	0.8	1.0	2.0	3.3	2.7
4	653.3	0.5	0.5	2.0	3.3	4.7	4.1
5	654.5	0.5	0.3	1.3	2.4	2.7	2.6
6	655.5	0.7	0.6	1.0	2.0	1.9	1.9
7	656.0	0.0	0.1	0.2	3.0	2.1	2.5
8	657.0	0.2	0.2	0.6	2.5	1.7	2.0
9	657.8	0.5	0.3	1.0	2.0	0.8	1.4
10	659.6	0.6	0.7	0.6	3.0	0.8	1.8
11	661.0	0.6	0.9	0.7	2.6	3.1	2.9
Average	-	0.5	0.5	1.0	2.2	2.3	2.3

(1) From McHenry and Ritchie, 1977.
(2) Determined by sampling cross-section plots at 500-foot intervals.
(3) Determined by planimetering area between 1937 and 1976 bottom contours on cross-section plots.

More complete information addressing sampling locations, particle size analysis and correlation, and Cs-137 concentration is contained in the references given for the tables.

The sediment rates in the preceding tables make it clear that all reaches of the study area are rapidly aggrading. Because different methods were used and sampling was fragmentary, the rates are somewhat conflicting. However, all of the data supports the conclusion that rapid sedimentation is taking place. Each method used (fathometer, spud, and Cs-137) may, by itself, be insufficient to make exact accumulation estimates, but when combined all methods support the same conclusion. The Cs-137 determinations tend to be the highest and the fathometer results the lowest. This was expected because the Cs-137 estimates were based on 10-centimeter sample increments (therefore 0 to 10 centimeters of sediment containing a given amount of Cs-137 was tabulated at 10-centimeter depth)(Ritchie, McHenry, Gill, 1972).

Calculated sedimentation rates vary by pool and location. Influencing factors are rate of water flow, concentration of suspended sediment, and location of tributaries.

Sedimentation rates indicate that a very real and urgent problem exists in those areas where fine sediments are depositing. Almost all the sampling sites are relatively shallow, slack-water areas where water depth is less than 5 meters. Few of the backwaters exceed a depth of 3 meters. A sedimentation rate of 2-3 centimeters per year is equivalent to 2-3 meters in a century. Thus, the problem of sedimentation must be resolved quickly or the backwater lakes and pools of the study area will cease to function as viable aquatic or semiaquatic habitats (McHenry and Ritchie, 1975).

CONCLUSION

The life expectancy of the backwater areas is limited if the present sediment flow continues. If the present rate of sedimentation is allowed to continue, most of the open water areas of the backwater lakes will succeed to marshland within the next century. Prevention of sediment production at the source is the only solution for extending the existence of the Mississippi River pools and backwater lakes. Soil conservation practices need to be applied to all potential sediment source areas.

CHAPTER III

SEDIMENTATION IN LAKE PEPIN

INTRODUCTION

Lake Pepin is truly one of the great natural resources of the Upper Mississippi River valley. This 22-mile long stretch of the Mississippi River corridor is the only naturally occurring lake in the study area. Lake Pepin has attracted a good deal of public interest because of its importance as a recreation resource. People who have lived in the Lake Pepin area for a long time have noticed physical changes in the lake. Those who have hunted and fished Lake Pepin are aware of areas they used to be able to cross in a boat that are now becoming clogged with emergent vegetation. In response to this public interest, the SEWG set out to determine the extent and nature of the problem in Lake Pepin. The work group had these objectives:

1. To determine the overall rate of sedimentation.

2. To identify the specific areas where sedimentation was occurring and to measure the extent of sedimentation in each area.

3. To determine the types of material present in the sediment.

4. To identify the source of the sediment.

5. To determine the need for corrective measures.

To properly address these objectives, the work group initiated studies to determine the nature and extent of the sediment problem in Lake Pepin.

RE-SOUNDING OF LAKE PEPIN

In 1895, the Corps of Engineers conducted a sounding of Lake Pepin. Records of this early sounding were located and an 1895 contour map of Lake Pepin was prepared by the work group. This map provides an excellent base line for measuring the "evolution" of Lake Pepin.

A 1976 contour map of Lake Pepin was prepared from data obtained through a new sounding of Lake Pepin. Even a casual comparison of the two maps shows the remarkable changes that have occurred between the two soundings. In 1895, large areas of open water were at the head of Lake Pepin. In 1976, almost no deep water areas remained in the Bay City, Wisconsin, end of Lake Pepin. While the comparisons at the head of Lake Pepin are most dramatic, one can pick almost any area of the lake, compare the two maps, and find that the lake has shallowed.

The map on page 23 reveals those changes caused by the sedimentation in Lake Pepin. This map was prepared by comparing the two contour maps and delineating the areas of sedimentation by depth of sediment deposits. The message is clear - Lake Pepin is filling in. In some areas, sedimentation is rapid. In the upstream end of Lake Pepin, the sedimentation rate exceeds 1 inch per year in many places. The reason for the greater rate of sedimentation at the upstream end of Lake Pepin is that this is the place where the rapidly moving waters of the navigation channel first meet the still waters of the lake. The rate of sedimentation decreases as one proceeds downstream through the lake. The large differential in sedimentation rates between the upstream and downstream end of Lake Pepin indicates that the sediment is probably coming from upland erosion sources. If the sediments were primarily limnic materials (lake originated), the sedimentation rate in the lake would be much more uniform.

SEDIMENT DATING

To get a more thorough picture of the sedimentation process in Lake Pepin, several other studies were initiated to determine the rates of sedimentation from 1960 to the present, sediment densities, and particle size distribution, and eventually to corroborate the data and conclusions from the two soundings of Lake Pepin. These studies were performed by the SEA Sedimentation Laboratory. Five ranges were selected across Lake Pepin. Each range was divided to equally space five boring sites across the lake. The drilling operation was conducted during the winter through the ice. The samples collected for Cs-137 analysis (McHenry et al., 1963; Ritchie et al., 1973) were taken to the laboratory where they were processed. Cs-137 concentrations and particle size distributions were determined. For discussion of the rationale and procedure used in the Cs-137 dating process, please refer to the section on fine grain sedimentation in the major pools.

SEDIMENT DENSITY

The SEA conducted a sediment density survey in cooperation with the St. Paul District, Corps of Engineers, to determine the consolidation of sediment layers. Sediment profiles were surveyed on the same ranges as established for sampling through the ice. On each range, sampling sites were located as close to the boring sites as possible. A raft was positioned on range and a heavy spud dropped. The spud held the raft securely on range while measurements were made. The probe was lowered vertically to a depth short of the indicated water depth. Standard or water density readings were made and then the probe was lowered in half-foot increments and readings of density made. As the probe was lowered into the sediment, the mass increased. The process continued until the probe could not be pushed farther into the sediment. A maximum of 9.5 feet of sediment was penetrated.

BORING ANALYSIS

As was also discovered in the comparison of the two soundings of Lake Pepin, the sediment sampling indicated that the depth of sediment accumulated decreased downstream through the lake averaging approximately 180 centimeters on the upstream range and 130 centimeters on the downstream range. The table on page 11 shows the summary of the Cs-137 concentration data by depth and range. These data indicate increased amounts of Cs-137 in the upstream sediment profile. Considerably lesser amounts of Cs-137 were found in the lower end of the lake. The data demonstrate that a considerably greater rate of recent sedimentation accumulation has occurred in the upper end of the lake and that the sediment in the upper end of the lake results from upland erosion. Further evidence is the fact that not only are the concentrations of Cs-137 per unit depth greater in the upstream profiles, but the depth of inclusion of Cs-137 in the profile is greater.

The estimates of sedimentation from 1895 to 1954 were 2.5, 2.3, and 2.7 centimeters per year for the stations at the upstream end of the lake and 2.4 and 1.8 centimeters per year at the downstream stations. The average sedimentation rates in Lake Pepin since 1954 are, therefore, somewhat less than for the period 1895 to 1954.

RESULTS OF STUDIES

Despite the apparent recent decrease in the rates of sedimentation in Lake Pepin, these rates are still high enough to be of concern. Deposition of 2 centimeters of sediment per year would be equivalent to a loss of 2 meters of water storage capacity in a century. This was the loss experienced during the past century. Continuation of this rate of sedimentation would transform much of the upper end of Lake Pepin into a marsh within three generations (McHenry et al., 1977).

The measurements of particle-size distribution indicate the sediments in all sampled profiles were essentially silty clays. The percentage of 2-micron clay increased somewhat downstream in the lake. The farthest upstream range sampled in this study is below the delta area in the lake because little sand has been carried this far into the lake. This indicates that the carrying capacity for coarse-grained sediments decreases as the current dissipates.

Sediment density measurements were made on all sites. Sediment densities, in the profile depths measured, are low, indicating high clay content. Densities increase with depth indicating compaction with passage of time.

The sediment profiles are very consistent, with extremely low densities at the surface increasing to 30 to 35 pounds per cubic foot in the lower end of the lake at about 8 feet and to 40 to 45 pounds per cubic foot at 7 feet in the upper end. This pattern indicates a long period of sediment accumulation with some segregation of the fines and their concentration in the lower lake.

The depth of sediment accumulated at the downstream end of the lake since 1895 is between 4 and 5 feet. No breaks or discontinuities are in the measured density values for the three deep profiles. It does not appear that the nature of the sedimentation process has changed since 1954, 1895, or earlier. If the accumulation of sediment from 1895 to the present is represented by the top 4 or 5 feet, the sediment density profiles probably go back to around 1800. On the upstream end of the lake the depth of sediment accumulated since 1895 is between 5 and 6 feet. The pattern of density is regular, increasing with depth and showing no particular change in the evaluation.

The sediments at the surface now with densities of 15 to 20 pounds per cubic foot will consolidate over the next 70 to 80 years to a density of 30 pounds per cubic foot and in 150 years to 38 to 40 pounds per cubic foot. This would mean a reduction in volume with time, estimated to be 33 percent in 75 years and 50 percent in 150 years. When considering the probable loss of water storage capacity in the lake resulting from sediment accumulation, the factor of compaction should be considered. Compaction will lessen the volume of water storage capacity lost.

An area of concern frequently mentioned in public meetings was sewage effluent from the Minneapolis/St. Paul area and the effect that organic material from this effluent has on the sedimentation rate in Lake Pepin. The percentage of organic matter contained in the samples is very similar to the percentage of organic material in surrounding upland soil - between 4 and 6 percent. These data seem to indicate that organic material from the Twin Cities sewage effluent is largely oxidized before it reaches Lake Pepin. In fact, the organic matter content of the sediment samples between the upstream and downstream end of the lake differs little. Thus, organic material from Twin Cities sewage effluent is not a significant factor in the sedimentation of the lake. Industrial and other inorganic pollutants may originate from upstream sewage effluent. This matter was addressed by the GREAT I Water Quality Work Group.

CONCLUSIONS

The rates of shoreline sediment accumulation in Lake Pepin have changed very little since 1895. The sediment density profile data indicate that the sedimentation pattern before 1895, perhaps back to the early 1800's, is very similar to that since 1895. No information exists on the rates of sedimentation prior to 1895, but the consolidation process appears uninterrupted. From 1964 to 1977, the sedimentation rate decreased from about 2.5 centimeters per year

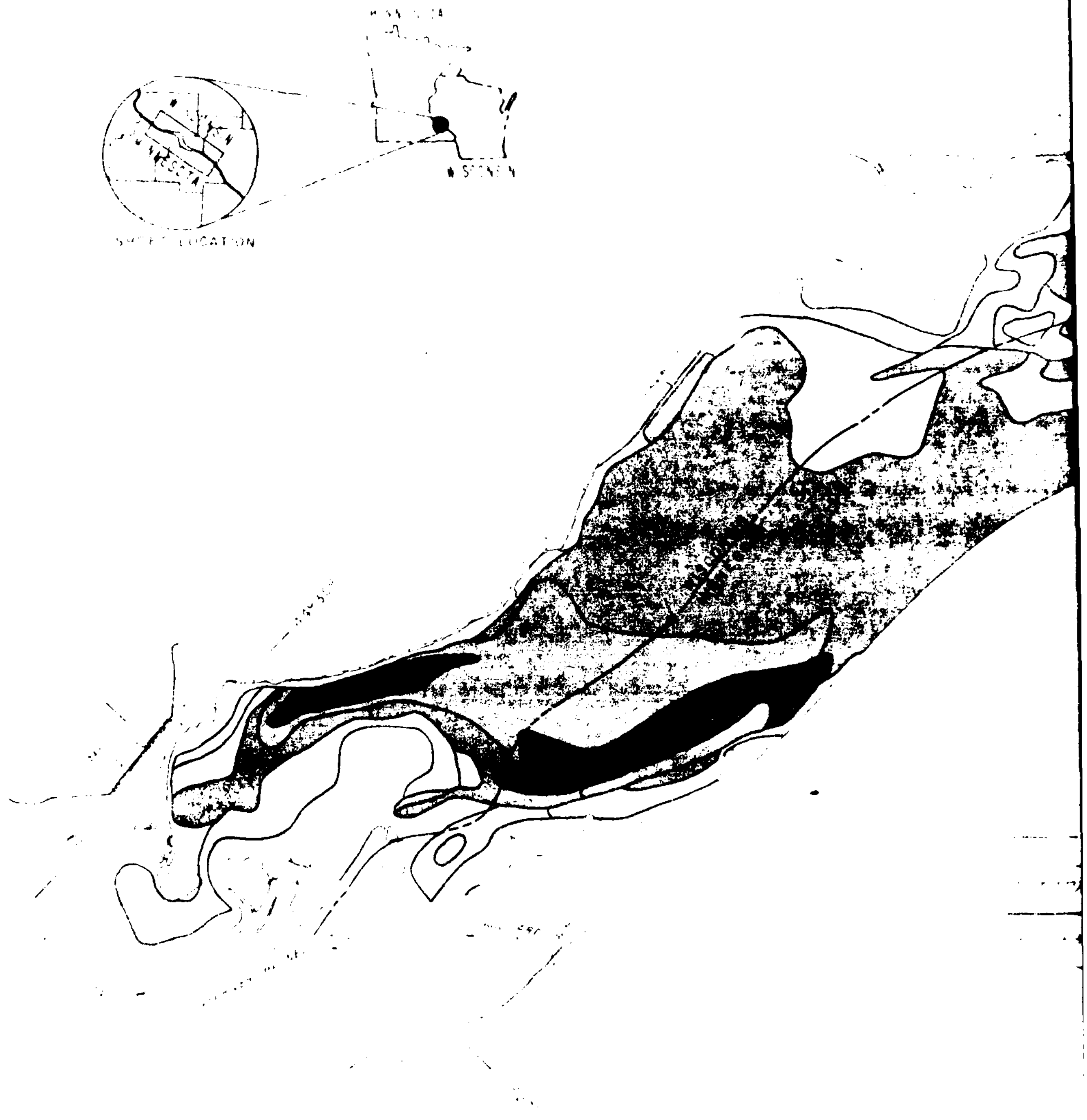
at river mile 782 to less than 0.5 centimeter per year downriver at river mile 767. From 1956 to 1964, the corresponding accumulation values are 2 centimeters and 0.5 centimeter per year. From 1895 to 1954, the calculated sediment deposition rates are approximately 2.5 and 2.1 centimeters per year, upper and lower ranges, respectively. These estimates of sedimentation rates are based on volumetric measurements. If corrections for differences in sediment density are made (the older sediments are generally more dense), the present sedimentation rates are less than those from 1895 to 1954. Throughout the area of the lake sampled, the sediments are silty clay in texture. The percentage of clay tends to increase downstream in the lake.

It is difficult to draw conclusions as to the reasons for the slight differences in sediment rates both in terms of time of deposition and location (upstream and downstream). In the early period of the study (1895 to the 1940's), the critical sediments source area identified in Chapter VI was farmed less intensively in terms of percentage of cropland. However, conservation practices during this time period were largely lacking. In the later period of the study, the farmland in the critical sediment source area has been cropped more intensively. However, better conservation practices were present. It is probable that the slight decreases in sedimentation rate actually indicate a larger effect of the increased rates of conservation practices applied because a decrease in sediment accumulation has occurred in spite of the great increase in the amount of land in the critical sediment source area which is cultivated (particularly in row crops).

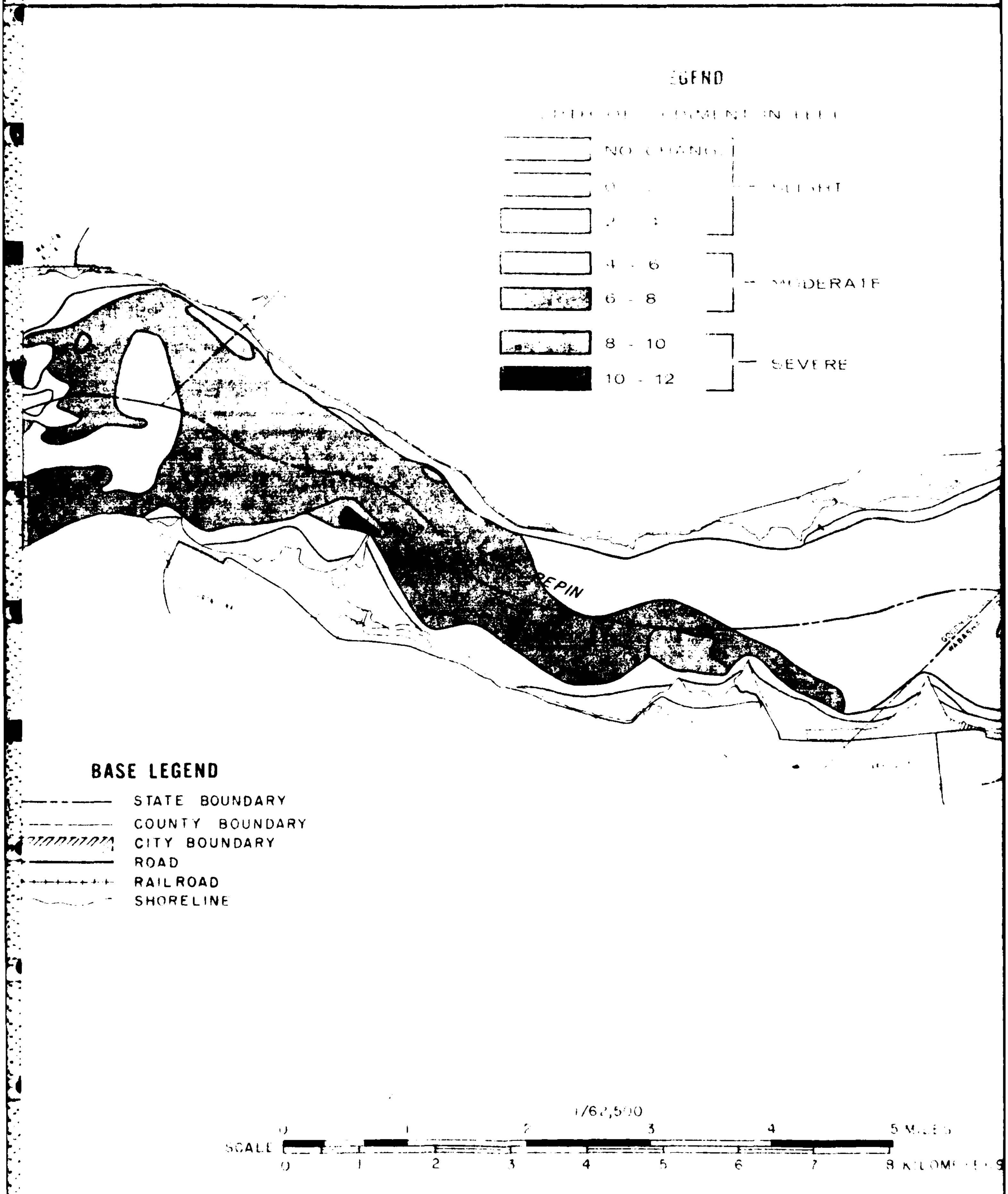
Although the present rates of sediment accumulation are no more and probably less than the average for the past 80 years, these rates are great enough to be of concern. The Cs-137 sediment dating study and the comparison of the bottom contour maps indicate that the upper end of Lake Pepin is seriously threatened by sediment and its environmental value will probably be lost in the very near future. Environmental degradation of the middle and lower parts of the lake will occur over

a greater period of time. Sediment studies clearly indicate progressively larger rates of sedimentation as one proceeds up-stream through the lake. This observation, coupled with the particle size analysis which indicates that the sediment is largely silt and clay, points to the fact that the source of sediment in the lake is upland erosion. Therefore, the focus of any program to halt the sedimentation of Lake Pepin must be directed toward curtailing upland erosion. Clearly, increased soil and water conservation in the sediment source area represent the only long-term hope for saving Lake Pepin.

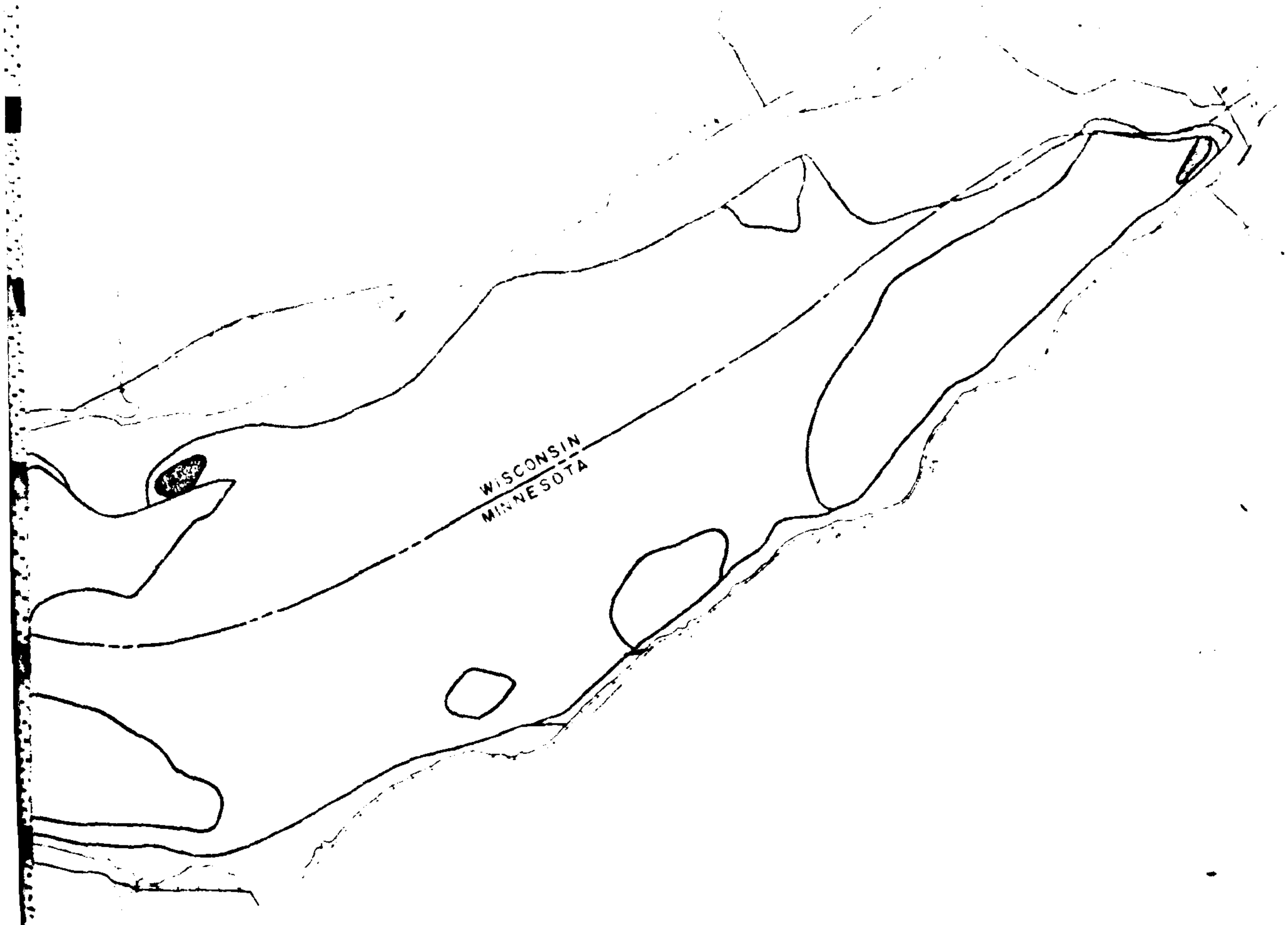
U.S. DEPARTMENT OF AGRICULTURE



SOURCE
SCS DRWG. NO. 5,P 36,862 (5-78) AND
INFORMATION FROM FIELD TECHNICIANS
PROJECTION UNKNOWN



4 - 6
6 - 8
8 - 10
10 - 12
SEVERE
BASE LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
CITY BOUNDARY
ROAD
RAILROAD
SHORELINE
1/62,500
SCALE
0 1 2 3 4
0 1 2 3 4 5 6 7 8



SEDIMENTATION OF

LAKE PEPIN FROM 1895 TO 1976

GREAT I

UPPER MISSISSIPPI RIVER BASIN

IOWA, MINNESOTA, SOUTH DAKOTA AND WISCONSI

CHAPTER IV

CHIPPEWA RIVER EROSION AND SEDIMENTATION STUDY

INTRODUCTION

The SEWG identified the Chippewa River as a major source of sand in the Upper Mississippi River system and selected the Chippewa River for intensive study. The work group also recommended that the Corps of Engineers select the Chippewa River for an erosion control demonstration project authorized by the Streambank Erosion Control Evaluation and Demonstration Act of 1974.

The purpose of the demonstration program is to illustrate inexpensive and innovative bank protection measures. During the first year of the 5-year program, erosion control measures will be installed. Their effectiveness will be monitored for the remainder of the program. Construction on the Chippewa River will begin in 1979.

GREAT has placed major emphasis on preparing a long-term channel maintenance plan, including predicting dredging requirements. Therefore, any knowledge gained from the Chippewa River demonstration project will apply directly to development of the maintenance plan.

The results of the project will also be used in the Chippewa River erosion and sedimentation feasibility study being conducted under GREAT. Thus, it is desirable that the successes or failures of the project be known before the final feasibility report is completed. Preliminary results of the feasibility study will be included in the GREAT I report. The feasibility study, however, will be completed under the authority of the 11 December 1969 resolution of the House of Representatives Committee on Public Works which requested a study of water resource problems in the Chippewa River basin. The final feasibility report is scheduled for 1986.

The demonstration project and feasibility study will provide important information to the GREAT study. Their dual purpose is to:

1. Determine the feasibility of implemented control measures and the extent that erosion and resultant deposition can be reduced.

2. Act as a pilot project to gain information about erosion and sedimentation problems in other critical tributary and watershed areas.

THE EROSION PROBLEM

Soil erosion has been a problem in the Chippewa River basin for many years, particularly in the lower reaches downstream from Eau Claire, Wisconsin. Farms in the hilly areas with deeply entrenched drainage courses are the most seriously affected. In 1933, the Federal Government initiated a nationwide erosion control program carried out by Civilian Conservation Corps camps under the technical guidance of the Department of Agriculture. Soil conservation activities were initiated in the Chippewa River basin in 1933 and have continued with increasing coverage.

Methods of application have changed. Since 1939, the counties have been organized into soil conservation districts under a 1937 Enabling Act by the Wisconsin Legislature. The Soil Conservation Service of the Department of Agriculture provides the planning, engineering, and guidance under the provisions of Public Law 566 and other acts.

"The Natural Resources of Wisconsin" dated December 1956 shows that, as of 30 June 1954, there were 730,000 acres in 4,830 farms in the basin under soil conservation programs. This work is being accelerated, according to the State Conservationist in Madison, Wisconsin.

Bank ersoion and resulting deposition have long been recognized as severe problems along the Chippewa River especially in the lower reaches below Eau Claire. Erosion of riverbanks composed of sand and fine gravel undermines the toe of the bank causing shore material to slide into the channel thereby resulting in loss of floodplain land. More crucial, however, is the effect that the eroded material has as it is swept downstream and redeposited.

Water and sediment moving through the Mississippi and Chippewa Rivers are affected by lock and dam 4. At low and intermediate flows, the dam raises the pool level above the natural river level. This increases the flow depth in pool 4 of the Upper Mississippi and the lower Chippewa Rivers. The backwater of pool 4 can affect the Chippewa River up to 6 miles above its mouth, decreasing the ability of this river reach to transport sediment. The result is deposition in the lower reach of the Chippewa River at low and intermediate flows.

With flood flows, the gates at lock and dam 4 are opened and flow conditions approach the natural river state. During floods, the sediment deposited on the Chippewa River bed during periods of low and intermediate flow is flushed downstream to the Mississippi River. The amount often exceeds the sediment transport capacity of the Mississippi River. This results in deposition in pool 4 below Lake Pepin and to a lesser degree farther downstream. It is these areas of excessive deposition that require recurrent dredging to maintain the navigation channel. The erosion and deposition depends greatly on the relative magnitudes of the Mississippi and Chippewa River flows.

Dredging records for the pool 4 reach in the Upper Mississippi River indicate that the most troublesome crossings that require frequent dredging are between river miles 762.4 and 763.8 near the mouth of the Chippewa River, between river miles 758.9 and 759.6 above Hershey (Crats)

Island, and between river miles 757.1 and 758 near Teepeeota Point. The dredged volumes in these three reaches were 2,120,000, 3,188,000, and 2,473,000 cubic yards, respectively, between 1936 and 1972. These reaches are straight and the flow is divided by alluvial islands. The dredging in these reaches accounted for about 78 percent of the total dredging in pool 4 downstream of Lake Pepin between 1936 and 1972. The total dredged volume reported in this river reach was 9,913,000 cubic yards during this time. Assuming that the unit weight of the dredged material was 100 pounds per cubic foot, the bed material dredged from this river reach averaged about 360,000 tons per year.

It has been verified that the Chippewa River is the major source of coarse sediment contributing to dredging needs in pool 4. By virtue of its comparatively steep gradient, high velocity, and easily eroded banks, the Chippewa River transports more sediment per unit volume of water than the Mississippi River. It carries several hundred thousand cubic yards of coarse material to the Mississippi River each year. Based on a rough estimate, the total weight of this material is about 500,000 tons per year. Much of this material is dredged from the Mississippi River to maintain the 9-foot navigation channel. It is estimated that the Chippewa River is responsible for about 20 percent of all maintenance dredging along the Mississippi River within the St. Paul District. Also, it has been estimated that in pool 4 below Lake Pepin the bed material dredged in a year weighed about 360,000 tons, which is less than the total bed-material load transported from the Chippewa River into the Mississippi River. Because some of the Chippewa River sediment affects the Mississippi River as far downstream as pool 5A, it is evident that this dredged amount exceeded that actually required to maintain the navigation channel. The practice of overdepth and overwidth dredging plays an important role affecting the dredging quantities.

Other factors that influence dredging requirements include:

1. Extended periods of abnormally low flow where lack of water in the system becomes a controlling factor.

2. Extended periods of unusually high flow.

3. Effectiveness and efficiency of dredging operations.

Before GREAT was formed, the Corps maintained the navigation channel in the most economical manner, giving little consideration to environmental damage. In addition to direct covering of productive habitat, seasonal high flows cause secondary movement of sand into side channel openings, backwaters, and other habitat areas. Since GREAT was established, an on-site inspection team composed of agencies participating in GREAT has worked with the Corps to select disposal sites that would have minimal environmental damage and would comply with Federal and State regulations.

NEEDS AND DESIRES

The overriding water resource need of the lower Chippewa River basin appears to be control of streambank and streambed erosion.

DEVELOPING A PLAN (PLAN FORMULATION)

The purpose of plan formulation is to develop a plan to provide the best use of resources to meet the identified needs of the basin. Two stages of plan formulation have been completed for this report. The first stage was to determine preliminary feasibility of a complete range of alternatives. The second stage is an iteration of the first concentrating on the evaluation of alternatives found most feasible. A third stage of plan development is yet to follow. This stage will involve the selection of a final plan of improvement which will be recommended to Congress for implementation. As stated earlier, however, this stage will be postponed until after results of the erosion demonstration program are known.

Stage I Formulation

The intent of preliminary feasibility formulation is to identify, evaluate, and compare alternative measures with a view toward feasibility and acceptability. A set of specific planning objectives guided this initial stage in the formulation process. These specific planning objectives are components of the national objectives of NED (national economic development) and EQ (environmental quality) and include:

1. Preserving the quality of the existing riverine environment to the maximum extent possible and enhancing the environmental and recreational potential of the rivers, lakes, and reservoirs in the Chippewa River basin.

2. Providing erosion control measures along the lower Chippewa River which recognize land losses and emphasize sediment reductions to be realized downstream along the Chippewa River and Mississippi River navigation channel.

In addition to the above specific planning objectives, various indirect social and environmental constraints guided development and acceptability of the alternatives. These included:

1. Developing a plan that is responsive and acceptable to the local people's desires and needs.

2. Enhancing the social well-being of the area.

3. Recognizing the national significance of the Chippewa River Bottoms, Buffalo County, Wisconsin, as a site included in the National Registry of Natural Landmarks, and potential landmarks (Nelson-Trevino Bottoms and Tiffany Bottoms Wilderness Area).

Possible Solutions. - Appropriate alternatives to meet identified study area needs were considered. Erosion and sediment reduction appear to be the most pressing problems along the lower Chippewa River. Possible solutions have been incorporated with the alternatives developed principally to meet the traditional Corps mission.

Alternatives Studied. - Alternatives considered to reduce erosion along the Chippewa River and decrease the flow of sediment from the Chippewa River to the Mississippi River include:

Alternative 1. Increase storage of existing flood control dams in the Chippewa River basin to reduce downstream flood discharges.

Alternative 2. Install a sediment trap on the lower end of the Chippewa River.

Alternative 3. Establish a meander pattern in the Chippewa River below Durand, Wisconsin.

Alternative 4. Divert a portion of the Chippewa River flow into Lake Pepin.

Alternative 5. Divert a portion of the Chippewa River into a sediment basin formed by the backwater of pool 4.

Alternative 6. Install a low-head dam at the lower end of the Chippewa River.

Alternative 7. Install a series of low-head dams on the lower Chippewa River to reduce channel gradient.

Alternative 8. Use streambank erosion controls.

Selecting Alternatives for Further Analysis. - Selection of alternatives for further analysis in stage II formulation was based on the need for the best uses of natural and man-made resources in the basin. Alternatives were analyzed with respect to increasing national economic efficiency and enhancing environmental quality. Satisfying specific objectives relating to the needs and desires of the people in the basin guided initial selection of alternatives. The benefit-cost ratio, principle of net benefits maximization, and effects assessments with and without project conditions over the project life were the main tools used in evaluating the alternatives.

The alternatives analyzed all satisfy specific objectives to some degree. However, several of the alternatives have severe adverse impacts on these objectives or do not satisfy the constraints of the study and, thus, are not viable. Alternatives 3 (establish meander pattern), 4 (Lake Pepin diversion), and 5 (Buffalo Slough diversion) are not locally acceptable and would not preserve the Chippewa River Bottoms Natural Landmark and the other prospective landmark areas. These three, along with alternative 1 (increase upstream reservoir storage), rate low in preserving the riverine environment in the study area. None of the alternatives significantly benefit recreation but could perhaps be made to better satisfy this objective through additional measures. Flood control can best be solved by local projects designed specifically for that purpose.

The NED objective is satisfied by alternatives 5 through 8. These alternatives display positive net monetary benefits. Alternative 2 (sediment trap) could become economically attractive if a beneficial use for material dredged from the "trap" is found. Alternatives 1 (increase upstream reservoir storage), 3 (establish meander pattern), 4 (Lake Pepin diversion), and 5 (Buffalo Slough diversion) are not economically feasible and any scale of development would not make them feasible.

Environmental quality aspects of the alternatives range from significant enhancement of the environment to significant adverse impacts. Alternatives 1, 3, 4, and 5 would have significant net adverse impacts.

From the above discussion it is evident that the following alternatives warrant further investigation:

- Alternative 2 - Sediment trap.
- Alternative 6 - Low-head dam above the mouth of the Chippewa River.
- Alternative 7 - Series of low dams on Chippewa River.
- Alternative 8 - Streambank erosion control.

Stage II Formulation

Stage II is an iteration of Stage I. It is broken into two parts:

1. Further examination of the alternatives identified in Stage I as warranting additional study.

2. Combining of studied alternatives to formulate several plans that can be studied to implementation detail during Stage III.

Stage II Studies to Date. - The alternatives studied during Stage I that warrant further investigation are:

- Sediment trap.
- Low-head dam above the mouth of the Chippewa River.
- Series of low dams on the Chippewa River.
- Streambank erosion control.

Two combined alternatives were also evaluated:

- Streambank erosion control and a sediment trap.
- Streambank erosion control and a low-head dam above the mouth of the Chippewa River.

The specific objective of Stage II to date has been to further predict the physical environment of the Chippewa River basin from Eau Claire to the mouth for the with and without alternatives conditions over the 50-year study period. Evaluation of the with and without conditions is given in the following table.

Alternative	When effective	Hydrologic changes	Affected area in Chippewa River basin	Sediment reduction	Dredging requirement	Channel stability and geomorphic changes	Construction requirement
				Impacts of alternatives			
Without-project condition	N/A	Flow distributions through divided channels would be changed as a result of changed channel dimensions. However, these changes should not significantly affect flood stages.	N/A	Because of the increase in channel dimension as a result of erosion, the sediment supply from the Chippewa River to pool 4 would be reduced by 12 percent in the next 50 years on the average. This would be a reduction of about 60,000 tons in an average year.	The dredging requirement in pool 4 would be reduced by 15 percent in the next 50 years, or about 40,000 cubic yards in an average year.	1. During the 10 years the main channel of pool 4 below Lake Pepin would aggrade 0.7 foot. 2. The natural levee along the pool 4 banks, on the island, and near the mouths of backwater areas would grow about 0.3 foot in 10 years. 3. Sediment in the backwater areas would continue to accumulate at an average rate of about 0.1 inch per year. 4. Erosion along the Chippewa River would continue. In the next 50 years, the Chippewa flow would erode about 180 acres of floodplain, and the riverbed would degrade about 0.7 foot. The channel slope would decrease about 2 percent.	None
Alternative 1: Sediment trap at the lower end of the Chippewa River	Within 1 year after implementation.	Not significant.	Mainly the disposal site.	The annual reduction in the Chippewa River sediment supply would approximately equal the weight of the material dredged from the sediment trap. A sediment trap 3 feet by 500 feet by 2,000 feet (a volume of 117,000 cubic yards) would reduce the sediment supply by 218,000 tons in an average year, or by about 43 percent of the present sediment supply.	Considering the long-term effect, if the sediment trap was maintained every year, the dredging requirement in pool 4 would be reduced about 90 percent of the Chippewa River sediment reduction. A trap 3 feet by 500 feet by 2,000 feet would reduce the requirement by 145,000 cubic yards in an average year or about 54 percent of the present average dredging requirement.	1. The deposition in the main stem of pool 4 would be reduced depending on the Chippewa River sediment reduction. 2. Sedimentation rates in the backwater areas of pool 4 would not be significantly affected. 3. Reduction in the Chippewa River sediment supply would not significantly affect pools 5 and 5A unless the reduction was more than 70 percent of the original supply rate. 4. This alternative would not reduce erosion problems along the Chippewa River.	The sediment trap should be maintained yearly.

Impacts of alternatives (cont)

Alternative	When effective	Hydrologic changes	Affected area in Chippewa River basin	Sediment reduction	Dredging requirement	Channel stability and geomorphic changes	Construction requirement
Alternative 2: Low-head dam at the lower end of the Chippewa River.	Within 1 year after construction.	With a 10-foot dam in place, the flood peak would be raised 2.2 feet for an average flood and 3.5 feet for a 1-percent chance (100-year) flood.	The increase in flood stage would extend to river mile 6 and inundate an additional 1,100 acres of forest and marsh. In the long term, the effect could extend upstream to Durand as a result of sediment deposition upstream of the dam.	A 10-foot dam would reduce the Chippewa River sediment supply by 55 percent; a 6-foot dam would reduce the supply by 40 percent for a short period after construction. The effectiveness of the low-head dam would be reduced by half over 40 years compared to the without project condition, if the sediment deposited upstream of the dam was not removed. This would result in a reduction of about 170,000 tons per year for the 10-foot dam compared to the present sediment supply in an average year. This is about 34 percent of the present sediment supply in an average year.	In the long term the dredging requirement in pool 4 would be reduced by about 90 percent of the amount of Chippewa River sediment reduction. For example, a 10-foot dam would reduce the dredging requirement by about 113,000 cubic yards. This is about 43 percent of present dredging if the sediment deposited upstream of the dam was not removed.	1. The deposition in pool 4 would be reduced as a result of decreases in the Chippewa River sediment supply, while pools 5 and 5A would not be significantly affected by this alternative. 2. Floodplain erosion in the Chippewa River basin below river mile 9 would be reduced by 22 percent or by about 40 acres compared to the without project condition. 3. The Chippewa River upstream of mile 9 would remain essentially the same as the without project condition. 4. Deposition would occur behind the dam. The height of sediment deposition would be about six-tenths of the dam height.	Natural crushed rock at least 8 inches or soil cement rocks at least 1 foot in size could be used to construct the low-head dam. The material required for constructing a 6-foot dam and a 10-foot dam would be approximately 500 cubic yards and 2,000 cubic yards, respectively. The dam should be maintained and the sediment deposited above the dam should be removed to maintain the original efficiency of this alternative.

Impacts of alternatives (cont)

Alternative	When effective	Hydrologic changes	Affected area in Chippewa River basin	Sediment reduction	Dredging requirement	Channel stability and geomorphic changes	Construction requirement
Alternative 3: Series of low-head dams on the lower Chippewa River	Within 1 year after construction.	The proposed dams would block about one-half of the bank-full area at damsites, and in turn would raise flood stage 2 to 3 feet above the normal flood stage for an average flood and 3 to 4 feet above the normal flood stage for a 1-percent chance (100-year) flood. Because of the erosion and deposition sequence caused by dams, the channel slope would be reduced by about 20 percent in 40 years. This would reduce local velocity by about 10 percent and could affect propagation of floodwater.	The increase in flood stage would inundate an additional 2,430 acres of the lower Chippewa River floodplain including about 2,100 acres of forest land and 330 acres of farmland.	The sediment reduction achieved by the four-dam case would be about 3 percent more than that achieved by alternative 2.	The reduction in dredging requirement caused by the four-dam case would be about 3 percent more than that for alternative 2.	1. Effects on geomorphology of the Mississippi River would be similar to those caused by alternative 2. 2. The dams would reduce erosion upstream of the dams but would increase erosion downstream of dams. The overall decrease in floodplain erosion would be about 25 percent or about 45 acres. 3. The erosion and deposition sequence caused by dams would reduce the channel slope by about 25 percent in 40 years.	Dams would be constructed using 8-inch natural crushed rock or 1-foot soil-cement rock. The material required for construction would be 2,000 to 4,000 cubic yards for the series of dams studied. The dams should be maintained, and the sediment deposited above the dams should be removed to maintain their original effectiveness.

Impacts of alternatives (cont)

Alternative	When effective	Hydrologic changes	Affected area in Chippewa River basin	Sediment reduction	Dredging requirement	Channel stability and geomorphic changes	Construction requirement
Alternative 4: Streambank erosion controls	Immediately on controlling bank erosion but slowly on sediment reduction.	Depends on the types of control structures. Revetment would not cause significant effect. Wing dam would constrict channel causing some backwater effect.	Depends on the types of control structures. Revetment would not cause significant effect. Wing dam would constrict channel causing some backwater effect.	In about 40 years, the sediment supply would be reduced by about 15 percent compared to the without project conditions. In an average year, the sediment supply would be reduced about 126,000 tons, or about 25 percent of the present sediment supply.	In a long term, the dredging requirement would be reduced by 84,000 cubic yards, or about 30 percent of the average present dredging requirement.	1. Effects on geomorphology of the Mississippi River would be similar to those of alternative 2 but to a smaller degree. 2. Protection of the nine identified erosion sites would save 60 acres of the Chippewa River floodplain from erosion, or about 30 percent of the total floodplain areas to be eroded in the next 50 years if riverbanks were not protected. 3. The Chippewa River would degrade about 1.1 feet in the next 50 years, reducing bed slope about 0.06 foot per mile (a reduction in slope of 3 percent).	Various types of erosion control structures are proposed. They include bank revetments constructed of crushed rock and soil-cement rock, wing dams, vegetation, and timber piles. The structures should be properly designed, constructed, and maintained.

Impacts of alternatives (cont)

Alternative	When effective	Hydrologic changes	Affected area in Chippewa River basin	Sediment reduction	Dredging requirement	Channel stability and geomorphic changes	Construction requirement
Alternative 5: Streambank erosion controls and sediment trap at the lower end of the Chippewa River	Within 1 year after construction.	Depends on the type of erosion control structures. The sediment trap would not significantly affect hydrologic variables. However, the dredged bed material disposed of on the floodplain would affect the adjacent floodplain.	Depends on the type of erosion control structures. The sediment trap would not significantly affec affect hydrologic variables. However, the dredged bed material disposed of on the floodplain would affect the adjacent floodplain.	If the protective works and the sediment trap were maintained every year, this alternative would reduce the Chippewa River sediment supply by about 15 percent plus an amount equal to the weight of material dredged from the sediment trap, compared to the without project conditions. For example, a cut 500 feet wide, 2,100 feet long, and 3 feet deep would reduce the sediment supply by 275,000 tons per year or about 55 percent of the present supply.	In the long term, the dredging requirement in pool 4 caused by dredging a 500-foot by 2,100-foot by 3-foot sediment trap at the lower end of the Chippewa River would be 247,000 tons per year. This is a reduction of about 69 percent of the current dredging quantity.	1. Effects on geomorphology of the Mississippi River would be similar to those of alternative 1 but to a larger degree. 2. The changes in the Chippewa River geomorphology would be similar to those of alternative 4 except near the lower end where dredging of the trap would change the local bed contours.	The erosion control structures should be properly designed, constructed, and maintained. Also the trap should be dredged periodically.

Impacts of alternatives (cont)

Alternative	When effective	Hydrologic changes	Affected area In Chippewa River basin	Sediment reduction	Dredging requirement	Channel stability and geomorphic changes	Construction requirement
Alternative 6: Streambank erosion controls and a 10-foot low-head dam at the lower end of the Chippewa River	Within 1 year after implementation.	Similar to alternative 2.	Similar to alternative 2	In the long term, the Chippewa River sediment supply would be reduced by 40 percent as compared to the without-project conditions if the deposited sediment upstream of dam was not removed. The reduction would total about 260,000 tons per year or about 52 percent of the present sediment supply.	In the long term, the dredging requirement would be reduced by 173,000 cubic yards per year, or about 65 percent of the original dredging requirement.	1. Effects on geomorphology of the Mississippi River would be similar to those of alternative 2. 2. Protection of the nine identified erosion sites would save 60 acres from erosion. 3. The Chippewa River would degrade about 1 foot in the next 50 years, except immediately upstream of the dam where the deposition height would be about 6 feet.	Bank erosion control structures and the low-head dam should be properly designed, constructed and maintained.

Conclusions of Stage II Studies to Date. - The selected alternatives should decrease bank erosion and sediment supply to the Mississippi River and improve the river basin for recreation, navigation, fish and wildlife, agriculture, and municipal and industrial purposes. The alternatives must have a favorable benefit-cost ratio. Alternatives 5 and 6 appear to be the most feasible. These alternatives would reduce the sediment supply to the Mississippi River and would significantly reduce the erosion problems in the Chippewa River basin. In terms of construction and maintenance costs, alternative 6 would be less expensive. However, alternative 6 would raise flood stages, inundating a large area near the mouth of the Chippewa River, and could increase flood damages. This alternative would also affect boat traffic. On the other hand, disposal of bed material dredged to form the sediment trap could adversely affect the river environment. The costs of construction and maintenance and the adverse impacts on the river environment versus the benefits derived from reduced bank erosion, better use of the river for recreation and navigation, floodplain development, and reduced dredging requirements in pool 4 are the major factors to be considered in developing the final plan.

Further Stage II Studies. - Stage II studies will be completed in early 1980 in time for the GREAT I final report. Studies will concentrate on the physical and environmental evaluation of the identified erosion control measures. These measures will be combined to develop NED, EQ, combination, and nonstructural plans. Each plan will be optimized as to scale of development so that net benefits are as high as possible.

The following tasks will be done to define existing conditions:

1. Inventory each resource.

2. Determine which resources are significant for the study area.

3. Develop resource profiles of existing conditions.

4. Project resources to the base year (1990).

5. Describe the base condition by organizing projections into a hierarchy.

6. Identify inadequacies in the data relative to completeness, reliability, validity, etc.

The environmental, physical, and land use conditions identified and quantified for existing conditions will be projected over the 50-year study period (1990-2040). The most probable future will be established along with at least one other likely future condition. Analysis of the without project condition will serve as the base line to which plans for water and related land resource improvements will be compared.

A mathematical streamflow model will be used to determine river response to the two combination alternatives listed above for further study. A combination considering a dam near the mouth of the Chippewa River with a sediment trap (dredging behind the dam) and another combination alternative will be considered.

From these alternatives a candidate NED framework plan, a candidate EQ framework plan, and a candidate combination plan will be developed. In addition, a nonstructural plan that satisfies objectives of the study will be identified. Measures that may be included in the nonstructural plan are modification of operating plans of upstream reservoirs, planting to reduce bank erosion, and modified maintenance dredging requirements that would preclude use of structures to reduce sedimentation and erosion. During Stage III, the candidate framework plans identified above will be further developed and optimized.

The impacts of the plans will be analyzed to compare the with and without project conditions. This information together with the results of the demonstration program will lead to recommendation of a plan to control erosion on the lower Chippewa River. This recommendation will be included in the feasibility report scheduled for submission to Congress in 1986.

CHAPTER V

CHANGE IN AQUATIC HABITAT, 1939-1973, POOLS 5 THROUGH 10

INTRODUCTION

The work that has been done with Cs-137 sediment dating, spud surveys, fathometer recordings, and the resurvey of Lake Pepin has established that sedimentation is occurring rapidly in the GREAT I reach of the Mississippi River. The cartographic work presented in this chapter attempts to describe where this sediment is being deposited and the relative amount of aquatic habitat being lost to sedimentation.

STUDY DESCRIPTION

The University of Minnesota interpreted the types of vegetation present on a series of preimpoundment (1939) aerial photographs of pools 5 through 10. The same process was performed on a set of 1973 photos. By comparing the types of vegetation identified on each set of maps, the areas of open water in 1939 which have been converted (lost) to emergent aquatic habitat were delineated. In addition, areas which changed from emergent aquatic habitat in 1939 to open water in 1973 were also identified. Because emergent aquatic vegetation exists in permanently anaerobic sediments (Wetzel, 1975), the areas which changed from open water to emergent aquatics were determined to be the locations of fine sediment deposition. Locations that show shifts from emergent plants to open water are assumed to be erosion or scour areas.

Despite efforts to minimize variations, location inaccuracies, pool elevations, and time of year discrepancies during photographing caused some error. However, the data presented by this technique clearly demonstrate the habitat changes that have occurred.

CARTOGRAPHIC REVIEW

To illustrate the extent of habitat conversion, the SEWG (through the Soil Conservation Service) prepared a set of 22 maps (pools 5 through 1[illegible] and an index sheet which depict the three changes that have taken place:

1. Loss of open water areas to fine sediment deposition.

2. Loss of open water areas to dredged material disposal.

3. Increase in open water areas caused by erosion.

Several variables must be noted when reviewing these maps:

1. The large areas of open water aquatic habitat which have been converted to emergent aquatic vegetation as a result of fine sediment deposition.

2. The location of habitat lost within the river corridor.

3. Comparison of areas lost to fine sedimentation and disposal of dredged material.

4. Effects and location of contributing tributaries and the associated loss of habitat to sedimentation.

5. Effects of in-channel flow and water level control devices including locks and dams and particularly dikes in relation to the location of habitat loss areas.

RESULTS

The 22 maps clearly show that tremendous amounts of open water areas have been converted to emergent vegetation habitat since impoundment, reflecting rapid and widespread deposition of fine sediments. Loss of aquatic habitat as a result of dredged material disposal is negligible when compared to areas affected by fine sedimentation. By comparison, then, the greatest extent of sedimentation-caused environmental degradation which is occurring in the river corridor is caused by fine sediment accumulation. Any remedial action should place highest emphasis on prevention of fine sediment deposition. Prevention of sediment production at the source is ultimately the only solution to this problem. Data gathered and determinations made in chapters 2 and 3 conceptually corroborate the information portrayed by the maps.

Pool-by-pool comparisons indicate that several pools appear to be aggrading and losing habitat faster than others. These variances can be explained in most cases by locating incoming tributaries and observing habitat changes downstream from their points of confluence with the Mississippi River.

Areas below tributaries which have lost extensive aquatic habitat indicate high fine sediment yield from those drainage areas (see Wamandee Creek - sheets 4, 5, and Upper Iowa River - sheets 15-16). If little habitat loss occurs below tributary confluence, relatively small amounts of fine sediment enter the Mississippi River from that drainage area (see Wisconsin River - map 20-21).

Because sediments remain in suspension as long as flow capacity supports them, areas exhibiting low flow are most prone to sedimentation of fines. Lower pool lakes, backwaters, and off-channel sloughs typically possess low-flow tendencies and are therefore the most susceptible to fine sedimentation.

As previously described in this report, abatement of fine sedimentation and its related environmental damage depends on prevention of erosion at the source - areas in agricultural use. However, in-channel measures can be used to eliminate or reduce the environmental impacts of fine sedimentation. Dike construction at critical habitats would prevent fine sediment from entering the isolated area and therefore prevent fine sedimentation. GREAT's Fish and Wildlife Work Group (FWWG) has examined the potential of dike construction with flow regulating devices such as closing dams and gated culverts to rehabilitate declining backwater habitat. While such diking may be feasible for restoring environmental value, careful engineering analysis must be made on a site-by-site basis so that other problems, particularly flood elevation increases and winterkills of fish, are avoided.

The Corps of Engineers ongoing shoreline protection program can prevent habitat loss or decline from fine sedimentation. Under this program, rock riprap is placed at main channel border areas to prevent bank erosion and secondary movement of dredged material caused primarily by towboat prop wash and seasonal flood flows. When riprap is placed on both banks of side channel openings, water flow constriction prevents coarse sediments from depositing, and, therefore, freshwater supply to backwater areas is maintained. Shoaling at these openings is more likely to occur if they are unprotected. If closure results, backwater areas are deprived of consistent flow and are prone to aggradation of fine sediments. The SEWG and two other GREAT work groups (the Fish and Wildlife and Dredging Requirements Work Groups) have prepared a list of areas which should be protected by riprap under the shoreline protection program. Protection at these areas will help prevent further decline of backwater areas by fine sedimentation.

CONCLUSIONS

The change in aquatic habitat maps illustrate that a tremendous amount of open water area has been converted to emergent aquatic vegetation over the last 34 years, indicating widespread accumulation

of fine sediments in pools 5 through 10. The fine sedimentation causing habitat degradation encompasses significantly more area than does dredged material disposal.

As corroborated by the sedimentation rates, widespread fine sedimentation will only be remedied by controlling erosion of upland areas under agricultural use. In-channel sediment abatement measures, including diking and shoreline protection, can be used at strategic locations to help prevent further decline of habitat by preventing fine sediments from accumulating.

Pages 44 thru 66
not included. See
DD1473 and 1st. Page.

CHAPTER VI

EROSION AND LAND TREATMENT

EROSION

Geologic erosion occurs when water, wind, or other erosive agents move soil or rock from slopes that have not been disturbed by man. Geologic erosion created many of our natural terrain features including the Mississippi River valley which was created by the erosive forces of ancient glacial meltwaters.

The greatest amount of erosion is man-made or accelerated erosion that has resulted from the practices of agriculture and urban development. When the natural covers of grasses and forests were removed by the early settlers, potential for erosion increased enormously. The process of soil erosion by water consists of three principal steps:

1. The loosening of soil particles by the impact of rainfall or the scouring action of running water.

2. Movement of the detached particles by flowing water.

3. Deposition of the particles at new locations.

Whenever rain falls faster than it can soak in, a sheet of water collects on the surface and moves downhill. The water dislodges the soil and keeps it suspended in the moving sheet of water feeding into little streams. The finest mineral and organic particles are carried in the runoff leaving the coarse or less fertile particles behind. This action of rainfall and flowing water which removes minute layers of soil is known as sheet and rill erosion. This type of erosion is responsible for the great majority of the soil erosion in the GREAT I study area.

As small streamlets or rills carry soil, the abrasive particles that the water carries in suspension may help the water to scour the sides and bottom of the channels. As these rills form into larger streams, the water flows faster and the scouring action increases. The result of the scouring action in these larger channels is gully erosion. It is in the larger gullies and streams that the gullies form that the water velocities become sufficiently intense to carry the large coarse sand particles which eventually must be dredged from the river channel.

The final step in the erosion process is sediment deposition. Deposition occurs as the water flow slows in the river channels and backwaters. Soil particles are sorted in the deposition process primarily as a function of flow velocities. The ability of the river to transport soil particles or sediment downstream (in suspension or along the bottom) is called carrying capacity. Because impoundment of the Mississippi River has created a series of slack-water pools where flow velocities are decreased as tributaries near the river, their flow also tends to decrease. The result is that the heaviest sediment particles being transported downstream will drop out near the mouth of the tributaries, often forming sand deltas or shoals in the main channel. This accumulation of sand requires dredging to maintain the 9-foot navigation channel. Finer sediment particles remain in suspension as long as the river carrying capacity supports them. When the current velocity further slows in backwater areas or open water pools, the fine particles settle out.

Streambank erosion in tributaries is responsible for most of the coarse material that deposits in the river channel. However, sheet and rill erosion on upland cropland areas is responsible for most of the finer sediments which are deposited in the backwater areas.

Before detailed studies of the quantity of erosion could be carried out, it was necessary to determine the geographic area which was responsible for the bulk of the fine sediment. It was also necessary to locate those areas on tributary streams which were responsible for the bulk of the sand deposited in the river channel.

SOURCE OF COARSE SEDIMENTS

The sand source map on page 74 was produced by mapping critical streambank erosion areas that were identified in a streambank erosion survey prepared by the Corps of Engineers. The erosion sites were identified by an on-the-ground survey of the principal tributaries in the area. Streambank erosion areas that were in drainage areas above sediment trapping reservoirs or lakes were excluded from the map.

A narrative discussing streambank erosion control alternatives on the Chippewa River - the highest sand contributor to the Mississippi River in the GREAT I area - is discussed in Chapter IV.

SOURCE OF FINE SEDIMENTS

The following map showing sediment sources was prepared by the work group using generalized soils maps and a knowledge of geology of the region. The critical sediment source area (colored area) depicting the sources of fine sediment does not incorporate the entire drainage area of GREAT I. The reason for this was that the critical sediment source area would not include drainage areas above lakes and reservoirs which serve as sediment traps. Other boundary areas were determined by the geologic characteristics of the region and the vegetative cover in portions of the GREAT I drainage area.

LAND USE AND EROSION CONTROL

Once the principal fine sediment source area was delineated, a detailed study of the erosion and sediment sources to the Mississippi River corridor could be undertaken. The basis for the erosion study in the critical sediment source area was the "1967 Soil and Water Conservation Needs Inventory" prepared by the Soil Conservation Service in cooperation with other agencies of the Department of Agriculture, Department of the Interior, and State of Minnesota. The inventory was a comprehensive survey of the status of soil and water conservation in the United States. Data were collected on land use, the status of conservation land treatment by land use, and the type of conservation practices that would be needed to adequately protect those areas which did not have adequate conservation practices installed. The work group decided that the inventory would form the basis for an update of soil and water conservation needs in the identified critical sediment source area. Questionnaires were mailed to the Soil Conservation Service's district conservationists in each of the counties in the identified sediment source area. The district conservationists were asked to update the information. They reported on changes in land use which had occurred since 1967 and projected land use changes for 1985 and 2000. Updated values for land adequately protected and land needing protection from soil erosion were provided and projected for 1985 and 2000. In addition to determining acreage by land use and status of conservation, the district conservationists produced an estimate of the average amount of erosion occurring for each land use both for adequately protected land and land needing protection. This information was used as the basis for estimating the amounts of gross soil erosion and costs of erosion control programs.

The following table shows a breakdown of the land which is in inventoried and noninventoried uses. Inventoried uses are those land uses which are predominantly agricultural. Noninventoried acreages are urban and built-up areas, Federal lands which are not in cropland, and small water areas. As shown in the table, the GREAT I sediment source area is predominantly inventoried land uses. An increase in the built-up and urban area is projected. However, this category is still a relatively small percentage of the total land use.

Noninventoried and inventoried land areas (acres)

Year	Noninventoried area: Federal non-crop	Noninventoried area: Built-up urban	Noninventoried area: Small water areas	Noninventoried area: Total	Inventoried area	Total
1975	161,000	383,000	28,000	572,000	8,354,000	8,926,000
1985	161,000	416,000	29,000	606,000	8,320,000	8,926,000
2000	162,000	457,000	30,000	649,000	8,276,000	8,925,000

The following table breaks down the land use of the inventoried acreages. Of inventoried land, cropland makes up the majority of the land comprising approximately 52 percent. Forest land makes up approximately 29 percent of the area. The sediment source area also includes a large acreage of pastureland - approximately 15 percent of the total land use. Use of inventoried land in the sediment source area for GREAT I is projected to remain relatively stable through the year 2000. Small changes will occur in other land uses such as roads, farmsteads, feedlots, ditch banks, hedgerows, and fences.

Land use in inventoried areas (acres)

Year	Land use: Cropland	Pasture	Forest land	Other	Total
1975	4,358,000	1,211,000	2,419,000	366,000	8,084,000
1985	4,356,000	1,178,000	2,418,000	368,000	8,320,000
2000	4,333,000	1,146,000	2,422,000	375,000	8,276,000

The following table indicates the principal types of land treatment that would be required to protect cropland needing land treatment. The land treatment need for most of the cropland is strip-cropping, terraces, and diversions. Except for permanent cover, this type of protection is the most intensive and expensive. The type of land which would require strip-cropping, terracing, or diversions would be sloping land in row crop rotations.

Conservation treatment needs, cropland in tillage rotation (acres)

Year	Treatment adequate, irrigated and non-irrigated	Nonirrigated cropland						Irrigated cropland, water management	Total tillage in rotation
		Residue and annual cover	Sod in rotation	Contouring only	Strip-crop, terracing, diversion	Permanent cover	Drainage		
1975	1,867,000	241,000	196,000	126,000	1,383,000	248,000	231,000	7,000	4,299,000
1985	2,117,000	213,000	171,000	115,000	1,265,000	214,000	189,000	11,000	4,295,000
2000	2,472,000	168,000	150,000	99,000	1,070,000	174,000	122,000	14,000	4,269,000

Erosion by land capability class is shown in the following table. The land capability classes reflect the relative erosion hazard on the land. Generally speaking, Class IIe land is land with a 2- to 6-percent slope; Class IIIe land, a 6- to 12-percent slope; Class IVe land, a 12- to 18-percent slope; Class VIe land, an 18- to 25-percent slope; and Class VIIe land, greater than a 25-percent slope. While the erosion rates per acre are very high for the Class VIe and VIIe land, the relatively small amount of these classes in cropland makes protection for them a lower priority concern. The primary emphasis in land treatment should be on the Class IIe, IIIe, and IVe land, which represents the bulk of the cropland needing treatment for erosion. Class IIe, IIIe, and IVe land also represents the land which is most feasible to protect. Class VIe and VIIe cropland needing protection is land which should not be in cropland. Therefore, the most feasible treatment would be a return to permanent cover.

Cropland in tillage rotation by class/subclass, 1975

Capability class	Acres	Land adequately protected			Land needing protection			Total tons per year
		Acres	Tons per acre per year	Tons per year	Acres	Tons per acre per year	Tons per year	
I	200,000	145,000	1.9	270,000	55,000	4.7	259,000	529,000
e								
II	1,055,000	434,000	3.0	1,315,000	621,000	7.2	4,453,000	5,768,000
III	1,114,000	453,000	3.6	1,649,000	661,000	10.4	6,895,000	8,544,000
IV	655,000	308,000	3.7	1,128,000	347,000	9.3	3,224,000	4,352,000
VI	234,000	88,000	3.8	336,000	146,000	11.0	1,603,000	1,939,000
VII	67,000	25,000	4.2	105,000	42,000	11.6	488,000	593,000
Total e	3,125,000	1,308,000	3.5	4,533,000	1,817,000	9.2	16,663,000	21,196,000
s	446,000	207,000	2.1	433,000	239,000	4.5	1,074,000	1,507,000
w	528,000	207,000	1.2	245,000	321,000	2.4	780,000	1,025,000
Total	4,299,000	1,867,000	2.9	5,481,000	2,432,000	7.7	18,776,000	24,257,000

Erosion prevention and land protection needs by land use for 1975, 1985, and the year 2000 are given in the following table. While the bulk of the sediment is coming from cropland needing protection, a significant amount of sediment is coming from pastureland and forest land. These land uses, if properly managed, should be contributing very small amounts of sediment. The primary treatment need is proper management. Pastureland which is grazed in a rotation and managed for maximum pastureland production will produce minimal (less than 1 ton per acre per year) erosion. Forest land properly managed, likewise, should produce minimal (less than 1 ton per acre per year) erosion. One solution would be to exclude livestock from forest areas. Forest land produces relatively little grazing value for livestock. However, it is expensive to fence forest from other pastureland. The farmer realizes no direct economic benefit. Proper incentives could be used to provide livestock exclusion from forest land and thereby reduce erosion to a minimal level. Other lands needing protection are roadsides and ditch banks. These areas often produce very high rates of erosion on a per-acre basis. In general, the costs of protecting this land would be extremely high on a per-acre basis. Therefore, the money might better be used on other lands where the erosion reduction per dollar spent would be much greater. First priority should be given to cropland, pastureland, and forest land needing protection.

Erosion prevention and land protection needs by land use

Year	Cropland LAP (1)	Cropland LNP (2)	Other cropland LAP	Other cropland LNP	Pastureland LAP	Pastureland LNP	Forest land LAP	Forest land LNP	Other land LAP	Other land LNP	Total LAP	Total LNP	Total
1975													
Acres	1,867,000	2,432,000	30,000	29,000	573,000	638,000	1,143,000	1,276,000	236,000	130,000	3,849,000	4,505,000	8,354,000
Tons per acre per year	2.9	7.7	2.1	7.9	1.9	5.6	1.5	4.8	2.4	14.1	2.3	6.8	4.7
Tons	5,481,000	18,776,000	62,000	228,000	1,086,000	3,543,000	1,765,000	6,097,000	576,000	1,835,000	8,970,000	30,479,000	39,449,000
1985													
Acres	2,117,000	2,178,000	32,000	29,000	598,000	580,000	1,197,000	1,221,000	244,000	124,000	4,188,000	4,132,000	8,320,000
Tons per acre per year	2.9	7.7	2.0	7.9	1.9	5.5	1.5	4.8	2.4	14.1	2.4	6.7	4.5
Tons	6,224,000	16,815,000	65,000	230,000	1,134,000	3,211,000	1,850,000	5,826,000	593,000	1,753,000	9,866,000	27,835,000	37,701,000
2000													
Acres	2,472,000	1,797,000	32,000	32,000	625,000	521,000	1,277,000	1,145,000	257,000	118,000	4,663,000	3,613,000	8,276,000
Tons per acre per year	3.0	7.7	2.1	7.7	1.9	5.5	1.5	4.8	2.4	14.1	2.4	6.7	4.2
Tons	7,312,000	13,865,000	67,000	245,000	1,189,000	2,867,000	1,973,000	5,462,000	624,000	1,657,000	11,165,000	24,096,000	35,261,000

(1) Land adequately protected from excess erosion.
(2) Land needing protection to reduce erosion to a level which would allow for the long-term survival of the soil resource base.

The following table shows the projected levels and costs of the ongoing land treatment program. This is the program that would take place with current funding levels and technology. Approximately 46 percent of the land in the critical sediment source area is adequately protected within Soil Conservation Service standards. The level of land adequately protected would increase to approximately 55 percent by 1985 and increase only slightly to the year 2000. The reason for this slower rate of progress from 1985 to 2000 is the amount of funding and technical assistance which would be tied up with renewal of the existing practices. It has been observed before that land treatment practices and land treatment structures are relatively short-lived. Renewal and replacement are necessary on a relatively frequent basis. With this increased level of protection, annual soil loss would decrease from the current level of about 39½ million tons to approximately 35 million tons by 2000. During this time period, some $50 million would be spent by 1985 to install land treatment measures which would achieve the 54.6-percent level of land treatment projected. By the year 2000, some $61 million would be spent in installing conservation practices. The table indicates that $8 million in technical assistance would be necessary to achieve the 54.6-percent level of land adequately protected and almost $10 million in technical assistance would be required by the year 2000 to achieve the 54.6-percent level of adequate protection. The last column in the table indicates the annual cost of maintaining conservation practices once installed. This is the cost of operation and maintenance and a sinking fund which would be required to replace or renew these practices. The annual cost of maintaining the level of land treatment projected for year 2000 would be $30.5 million. This increasingly high level of operation, maintenance, and replacement costs explains in part why the increase in the percentage of land adequately protected would taper off after 1985.

Cost of ongoing land treatment program[1]

Year	Land use	Total acres	Land adequately protected: Acres	Land adequately protected: Percent	Annual soil loss (tons)	Acres protected above 1975 base	Cost: Installation	Cost: Technical assistance	Cost: Total	Cost: Annual operation and maintenance
1975	Cropland	4,299,000	1,867,000	43.4	24,257,000					
	Other	4,055,000	1,982,000	48.9	15,192,000					
	Total	8,354,000	3,849,000	46.1	39,449,000					$25,058,000
1985	Cropland	4,295,000	2,117,000	49.3	23,039,000	250,000	$19,950,000			
	Other	4,025,000	2,426,000	60.3	14,662,000	444,000	29,748,000			
	Total	8,320,000	4,543,000	54.6	37,701,000	694,000	49,698,000	$8,328,000	$58,026,000	29,490,000
2000	Cropland	4,269,000	2,472,000	57.9	21,177,000	605,000	47,190,000			
	Other	4,007,000	2,191,000	54.7	14,084,000	209,000	14,003,000			
	Total	8,276,000	4,663,000	56.3	35,261,000	814,000	61,193,000	9,768,000	70,961,000	30,565,000

(1) All costs represent the cost of going from the 1975 level to the 1985 or 2000 level. Therefore, the cost of going from the 1985 to 2000 level would be cost for 2000 minus the cost for 1985.

EXISTING CONTROL ALTERNATIVES

The costs and benefits of three different levels of accelerated land treatment are presented in the following table.

Costs for various levels of land treatment, 1975 base

Plan	Land use	Total acres	Land adequately protected		Annual soil loss (tons)	Acres protected above 1975 base	Cost			
			Acres	Percent			Installation	Technical assistance	Total	Annual operation and maintenance
A	Cropland	4,299,000	3,091,000	71.9	18,695,000	1,224,000	$95,472,000	$14,688,000	$110,160,000	
	Other	4,055,000	2,756,000	68.0	12,190,000	774,000	51,858,000	9,288,000	61,146,000	
	Total	8,354,000	5,847,000	70.0	30,885,000	1,998,000	147,330,000	23,976,000	171,306,000	$38,318,000
B	Cropland	4,299,000	3,607,000	83.9	16,219,000	1,740,000	135,720,000	20,880,000	156,600,000	
	Other	4,055,000	3,076,000	75.9	10,945,000	1,094,000	73,298,000	13,128,000	86,426,000	
	Total	8,354,000	6,683,000	80.0	27,164,000	2,834,000	209,018,000	34,008,000	243,026,000	43,869,000
C	Cropland	4,299,000	4,299,000	100.0	12,897,000	2,432,000	189,696,000	29,184,000	218,880,000	
	Other	4,055,000	4,055,000	100.0	7,137,000	2,073,000	138,891,000	24,876,000	163,767,000	
	Total	8,354,000	8,354,000	100.0	20,034,000	4,505,000	328,587,000	54,060,000	382,647,000	54,631,000

Plan A, a 70-percent level of land adequately protected, is estimated to be the level of land treatment that would occur if funding were adequate to meet all of the requests for technical assistance and cost sharing to apply current land treatment practices. Plan A would reduce soil loss from a level of 39.5 million tons to approximately 31 million tons. The cost of installing the practices necessary to achieve the 70-percent level of land adequately protected would be $171 million. In addition, approximately $38 million would be needed annually to maintain the 70-percent level of land adequately protected.

Plan B, an 80-percent level of land adequately protected, is estimated to be the maximum level of land adequately protected possible with mandatory soil loss restrictions. Plan B would reduce the soil loss from 39.5 million tons to 27 million tons. Plan B would cost $243 million to implement and $44 million annually to maintain this level of land treatment.

Plan C, a 100-percent level of land adequately protected, is presented merely as a reference point. This condition is not likely to occur anytime in the foreseeable future. If this condition were possible, soil loss would be cut almost in half at a cost of $383 million with an annual cost of $55 million to maintain this level of land treatment.

With current land treatment practices the maximum possible soil loss reduction is approximately 50 percent. The relatively short life expectancy of some of the pools and the high cost of such a program protecting 100 percent of the land raises serious questions as to the total adequacy of current land treatment practices as a means of increasing water quality and reducing sedimentation in the Mississippi River corridor.

NEW CONTROL ALTERNATIVES

Conservation tillage systems which could reduce sediment yields and erosion rates to a level that would allow the long-term survival of the Mississippi River backwaters and Lake Pepin are being tried at the Hiawatha Valley Demonstration Farm in Winona County, Minnesota. The purpose of the farm is to demonstrate old and new methods of farming directed toward improved soil and water conservation. Many of the tillage practices demonstrated have been limited primarily to small plots and experiment stations. Tillage practices demonstrated included no till, till plant, and conventional mold board plowing. The first year's operation of the demonstration farm (1978) brought to light many of the problems of management, chemical application, and timing of field operations and chemical applications. One of the most striking things in the first year's data is that yields on no till and till plant systems compare quite favorably with yields on conventionally tilled ground. Many of the plots are located in an area where erosion on conventionally tilled land is 30 to 40 tons per acre. Erosion on land in no till cultivation systems is reduced from 30 to 40 tons per acre to 3 to 5 tons per acre. Yet, the yields on the no till land are only slightly less in many of the plots than the yields on the conventionally tilled ground. It should be pointed out that the demonstration farm is a "demonstration farm" and not an "experiment farm." The demonstrations were not carefully controlled scientifically. However, the demonstration plots do point out the enormous potential in no till and conservation tillage farming as ways to reduce erosion in critically eroding areas (Hansgen, 1978).

CONCLUSIONS

Further work needs to be done in the GREAT I critical sediment source area to fully determine the potential of no till and conservation tillage farming as ways to save the backwaters of the river. This study should direct itself toward determining:

1. The potential reduction in soil loss with the use of conservation tillage.

2. Changes in the farming practices which would be required by a change to conservation tillage farming. This would include studies of types of chemicals, rates of application, timing of application, changes in management practices, changes in types of machinery and equipment, and other adaptations which would be required by a conversion to conservation tillage farming.

3. Changes in yields and net returns which would result in conversion to conservation tillage farming.

4. Types and amounts of economic incentives which would be needed to induce widespread conversion to conservation tillage.

The ultimate method to curtail upland erosion in the critical sediment source area for GREAT I is believed to be a combination of the continued application of the traditional soil conservation practices and the application of new soil conservation practices oriented specifically toward the reduction of soil loss and the improvement of water quality. On the basis of the work done by the Hiawatha Valley Demonstration Farm, it appears that enormous potential exists to reduce sediment and improve water quality using conservation tillage farming. If it is demonstrated that conservation tillage farming is a viable means of reducing sediment and that it does reduce yields, a subsidy might be an appropriate way to induce farmers to switch to conservation tillage farming.

CHAPTER VII

CONCLUSIONS

The SEWG has studied the sedimentation problems which threaten the Upper Mississippi River as a valuable enrionmental, economic, and recreational resource. On the basis of studies conducted to determine the extent of sedimentation, the time constraints under which corrective action must be taken, and the consequences of the no action alternative, the work group has reached a series of conclusions which clearly identify a real and urgent sedimentation problem and point out what measures can be taken to solve the problem. While the conclusions reached from these studies were not unexpected, the relative totality of the sedimentation dilemma throughout the river corridor and the immediacy of potential irreversible impacts were unforeseen.

FINE PARTICLE SEDIMENTATION

Accumulation of fine sediments in backwaters, low-flow pool areas, and isolated side channels has caused significant loss of productive aquatic habitat in the period since impoundment. The water in these areas is shallow. If sedimentation continues at its present rate, much of this valuable habitat acreage will be converted into semi-aquatic marshland within the next century. The Upper Mississippi River, known for its fish, wildlife, and habitat diversity, will not retain its present environmental value unless immediate remedial action is taken.

The source of fine sediment is upland erosion. Therefore, any attempt to reduce fine sedimentation in the river corridor must focus on more environmentally sound land use practices. The critical eroding areas are identified on the sediment source map on page 76. This area should be given top priority for action to prevent further habitat loss to fine sedimentation. This is the only hope for extending the existence of the Mississippi River pools and backwaters.

Evaluation of current agricultural land treatment programs indicates that land treatment is an important means of curtailing upland erosion. However, current practices alone are not enough to provide a long-term solution to the sedimentation problem in the river. Measures that have a greater potential for erosion reduction than those in widespread practice will be necessary to reduce sedimentation to a level that will insure the long-term survival of the Upper Mississippi River backwaters.

Side channel alterations, diking flow manipulation, or other structural modifications within the river corridor may be practical for preventing further decline of critical wildlife areas. Such projects would not, however, be sufficient to solve the total fine sedimentation problem.

SAND SEDIMENTATION

A second problem of crucial concern is the accumulation of coarse sediment (sand). This sand must be periodically dredged to maintain the 9-foot navigation channel.

Sediment carrying capacity normally confines movement of coarse sediments to the bottom of the main channel. Thus, the problem originally is one of the economics of channel maintenance. These sediments create little disruption of biological activity along the bottom of the main channel. However, dredging and disposal seriously damage the more sensitive main channel border and adjacent backwaters.

Some of the problems caused by dredging accumulated sand sediments to maintain the channel are:

1. Loss of productive biological habitat at the main channel border and adjacent backwaters, side channels, and wetlands as a result of being covered by dredged material.

2. Turbidity and resuspension of sediment during dredging.

3. Habitat loss, side channel blockage, and potential reshoaling in the main channel caused by secondary movement of dredged material.

4. Secondary movement of dredged material that covers main channel border prime fish use areas (wing dams, snags, rocks, etc.).

5. Aesthetic degradation caused by sand piles.

The problems caused by sand accumulation in the river corridor can be alleviated by (1) control of sand erosion at the source, (2) more environmentally sound dredging and disposal techniques, and (3) in-channel protection measures. Streambank erosion control measures should be evaluated in terms of both economic and environmental benefits. Even when a measure cannot be justified on economics alone, consideration should be given to implementation when considerable environmental benefits can be expected.

SAND SEDIMENT EROSION CONTROL

The source of sand entering the river system is primarily bank erosion on tributary streams. Costs for bank stabilization projects are extremely high and often prohibitive. An exception is the Chippewa River which is the largest sand source in the GREAT I area. Approximately 360,000 tons of sand are dredged annually from a 6-mile area immediately below the confluence of the Chippewa and Mississippi Rivers. Significant reductions in dredging requirements (and related maintenance cost savings) alone make bank control at strategic locations on the Chippewa River feasible. Implementation of the most feasible control measures (to be determined by the Corps Chippewa River Basin Feasibility Study) on other critical tributaries (identified on the sand source map on page 70) may be practical and cost effective.

ENVIRONMENTALLY SOUND DREDGING PROGRAM

Although bank protection efforts to reduce sand flow into the Mississippi River are possible in many cases, cost constraints prohibit stabilization at all sand sources. Therefore, while bank protection measures could reduce dredging requirements, they will not replace the need to maintain the 9-foot channel. The Material and Equipment Needs Work Group is reviewing dredging equipment and capabilities and new designs to identify options that will reduce the impacts of channel maintenance on the environment.

Ideally, disposal of all dredged material should be made out of the river's floodplain. This would eliminate direct disposal on riverine habitat and prevent secondary movement of dredged material and its related impacts on the environment. Out-of-floodplain disposal is not always economically acceptable, however, because long distance disposal expenses exceed the Corps operation and maintenance budget. Until long distance disposal can be accomplished with new dredging equipment capabilities in a cost effective manner, disposal site selection will compromise dredging costs and potential environmental damage. GREAT has accomplished this balance in the Channel Maintenance Appendix and through the interagency on-site inspection team. The inspection team has identified the most environmentally and economically acceptable disposal sites and insures compliance with State and Federal disposal and water quality regulations.

IN-CHANNEL PROTECTION MEASURES

In-channel disposal will continue to take place until long distance capability is obtained. Every effort should be made to stabilize dredged material piles to prevent secondary movement. Vegetation on sandpiles would protect from flood flows and would prompt succession to a more natural and aesthetically acceptable habitat.

The Corps ongoing shoreline protection program has benefited the environment by preventing tow propwash and flood flows from eroding channel banks, thereby minimizing additional sediment input into the system. An extensive inventory and evaluation list prepared by several GREAT work groups (including the SEWG) has identified areas that need shoreline protection. The Corps should continue its shoreline protection program using the priority list prepared by GREAT.

RELATIONSHIP BETWEEN SAND AND FINE SEDIMENTATION

Although the accumulations of sand and fine sediments have been presented as separate problems, there is an unmistakable cause and effect relationship between them. The most obvious impact from sand accumulation is the habitat loss as a result of dredged material disposal. However, the secondary movement of this sand can potentially intensify fine sedimentation in backwaters and off-channel areas. When erosion of dredged material induces shoaling of coarse sediment at the mouth of a side channel, flow loss through companion backwater areas allows fine suspended sediment to settle out and thus accelerates fine sedimentation. Maintained flow through backwaters is also essential as a source of oxygen. Proper site selection and stabilization is of extreme importance for minimizing backwater sedimentation rates, habitat loss, and biological productivity.

NEED FOR EXPANDED DATA COLLECTION

Identification and monitoring of tributaries in the GREAT I area has been used to determine which tributaries are producing high sediment yields to the Mississippi River. Data gathering has been useful for recommending control for those streams with the highest sediment output.

Stream sediment monitoring and analysis are ongoing programs of the U.S. Geological Survey and the St. Paul District, Corps of Engineers. The SEWG, in cooperation with the Corps, has initiated monitoring studies of the Chippewa River to determine coarse sediment yield. This information will be helpful as base-line data to determine the sediment yield reductions and correlations caused by the Corps Chippewa River erosion control demonstration project. Establishment of monitoring stations on other identified tributaries or on tributaries previously not inventoried for critical yield analysis would help determine where control measures should be implemented and provide base-line data for analyzing the success of new sediment control systems.

CHAPTER VIII

SEDIMENT AND EROSION WORK GROUP RECOMMENDATIONS

RECOMMENDATION 1

Recommendation

Application of existing upland erosion control practices should be accelerated to the maximum extent possible. The critical sediment source areas identified on the "GREAT I Sediment Source Map" should have top priority for funding and implementation in the GREAT I drainage area.

Justification

The principal cause of the loss of fish and wildlife habitat in the Upper Mississippi River backwaters is the accumulation of fine sediments eroded from upland agricultural areas. This conclusion is based on an evaluation of the results of the following work group studies:

1. Particle size analysis of geologic borings.

2. Re-sounding of Lake Pepin.

3. Cs-137 sediment dating process.

4. Aquatic habitat comparison study.

Acceleration of the application of existing land treatment practices would result in a decrease in gross erosion from agricultural areas and in the ultimate deposition of this eroded material in the river system backwaters. The land treatment analysis indicates that an

80-percent level of land adequately treated would decrease upland erosion by one-third. Presently, 46 percent of the land within critical sediment source area boundaries is adequately treated according to Soil Conservation Service standards.

Procedure

Implementation should be carried out under the authority of the Rural Clean Water Program.

RECOMMENDATION 2

Recommendation

A two-phase study should be conducted in the GREAT I critical sediment source area to determine the feasibility of large-scale use of conservation tillage farming systems as a means of substantially reducing the sediment yield to the Mississippi River. In addition, the phase 1 portion of that study (as outlined below) would include feasibility analysis of additional soil conservation alternatives identified by members of an interagency river management team.

Phase 1 of the study would be designed to determine:

1. Potential reduction in soil loss.

2. Changes in farming practices that would be required. This would include studies of types of chemicals, rates of application, timing of applications, changes in management practices, changes in types of machinery and equipment and other adaptations which would be required by a conversion to conservation tillage farming or other soil conservation alternatives.

3. Changes in yields and net returns that would result from implementing conservation tillage farming or other alternative practices.

4. Types and amounts of economic incentives that would be needed to induce a widespread conversion to conservation tillage or other alternative soil conservation practices.

Phase 2 of the study would be an on-the-ground demonstration project in a watershed area identified as being a significant sediment source to the Mississippi River. The demonstration watershed would be closely monitored to determine the benefits of alternative land treatment practices and conservation tillage farming. Gaging stations would be established to monitor sediment delivery during the project. A comparison watershed would be monitored to determine existing or baseline conditions.

Justification

The Sediment and Erosion Work Group has determined that the life expectancy of several of the pools is very short - 50 to 250 years. The maximum erosion reduction theoretically possible with current soil conservation practices is 50 percent. Therefore, to preserve the pools for the long run, it will be necessary to develop soil conservation technology that will reduce erosion above and beyond the limits of the current program.

Procedure

Phase 1 should be conducted by the U.S. Department of Agriculture's Science and Education Administration under the guidance of the Soil Conservation Service. The demonstration project should be implemented

by the local soil and water conservation district, watershed dist[illegible] or other local sponsor. The project funding and direction should be provided by GREAT, an interagency, interdisciplinary coordination team. Technical assistance would be furnished by the Soil Conservation Service.

RECOMMENDATION 3

Recommendation

The Corps of Engineers should continue its program of the evaluation of the alternatives for sediment control on the Chippewa River. The two alternatives selected for further study in the Chippewa River basin preliminary feasibility report should be implemented if they are found to be feasible.

Justification

Bank erosion from the Chippewa River and resulting deposition of coarse sand into the Mississippi River has resulted in loss of floodplain land and increased channel maintenance requirements. Implementation of feasible bank erosion control measures would decrease erosion and its related impacts on the Mississippi River corridor.

Procedure

The Corps of Engineers should continue the Chippewa River basin study under its present authorities.

RECOMMENDATION 4

Recommendation

The Corps of Engineers should continue restoring and establishing shoreline protection on a yearly basis following the design and priority list prepared cooperatively by the Sediment and Erosion, Fish and Wildlife, and the Dredging Requirements Work Groups until completion.

Justification

Shoreline erosion within the river corridor increases the sediment load to the Upper Mississippi River. This accelerated sedimentation destroys fish and wildlife habitat and increases navigation channel maintenance requirements. Sedimentation will be slowed if shoreline protection measures are implemented.

Procedure

The Corps should continue restoring and establishing shoreline protection structures using existing authority and funding (River and Harbor Acts).

RECOMMENDATION 5

Recommendation

A follow-up to the Corps of Engineers "Streambank Erosion Site Inventory" should be conducted cooperatively between the Soil Conservation Service and the Corps of Engineers to determine and classify streambank erosion sites not previously identified. Alternatives for bank erosion control should be developed and analyzed for economic and environmental impacts. Implementation authority and cost-sharing criteria should be developed so that control alternatives can be accomplished.

Justification

Streambank erosion from tributaries has been identified as the principal source of coarse sediments entering the Mississippi River. Applied control measures on identified high coarse sediment contributing tributaries will reduce channel maintenance requirements and the potential secondary impacts on fish and wildlife habitat associated with dredged material disposal.

Procedure

The follow-up phase of this recommendation should be conducted cooperatively by the Soil Conservation Service and the Corps of Engineers. Program development should be conducted by those two agencies in consultation with GREAT.

RECOMMENDATION 6

Recommendation

Barren sand dredged material piles should be stabilized with vegetation.

Justification

While it is not felt that resuspended sand is a major source of coarse material requiring channel maintenance, every effort should be made to stabilize dredged material piles to avoid resuspension and damage to backwaters.

Procedure

The Corps of Engineers should adopt this policy as part of its standard operating procedures for channel maintenance under existing operation and maintenance authority.

RECOMMENDATION 7

Recommendation

Monitoring of sediment inflow from major tributaries should be continued. The U.S. Geological Survey should review all tributaries with GREAT to establish priorities for additional sediment sampling stations.

Justification

The existing monitoring programs of the Geological Survey have provided base-line information regarding tributary sediment contributions to the river corridor, as would newly established stations. These data will be useful for identifying priority watersheds for implementation of upland erosion control practices and streambank protection measures. Gaging station data should be used to determine site selection of the upland treatment demonstration project discussed in Recommendation 2.

Procedure

The Geological Survey should continue to expand its monitoring program under present authorities and in consultation with GREAT.

RECOMMENDATION 8

Recommendation

Diking of critical backwater areas threatened by sediment accumulation should be considered as an alternative protection measure. Water flow control structures should be provided, where appropriate, to insure exchange of fresh water during normal flow periods to prevent seasonal fish kills. Design should fully consider potential impacts on flood elevations.

Justification

Examination of the Meyer data in areas where dikes and levees exist indicates that the diking of backwater areas is a workable means of preserving critical fish and wildlife areas. The extent of fine sedimentation in backwater areas immediately behind dikes was considerably less than the sedimentation in areas not protected by dikes.

Procedure

The Fish and Wildlife Service, in consultation with GREAT, should identify critical backwater areas which may benefit from diking construction. Construction operations should be done by the Corps under existing 9-foot channel operation and maintenance authority expanded to include fish and wildlife preservation and enhancement as project purposes.

AFTERWORD

The following illustrations were prepared during the course of the study but were not included in the final report:

1. 1895 contour map of Lake Pepin.

2. 1976 contour map of Lake Pepin.

3. Cesium 137 sediment dating location map.

4. Location of geological borings, Lake Pepin.

5. Geological borings in the bottom of Lake Pepin.

Information regarding these illustrations is available from the Soil Conservation Service, 200 Federal Building and U.S. Courthouse, 316 North Robert Street, St. Paul, Minnesota 55101.

GLOSSARY

Aquatic habitat - An environment conducive to the life and reproduction of water-based flora and fauna.

Chisel, disk, or rotary tillage - Seedbed preparation performed over the entire surface area without inversion of the soil. Tillage and planting may or may not be accomplished in the same operation. A protective cover of crop residues is left on the soil surface to reduce soil loss.

Clay - Soil particles less than 0.002 millimeter in diameter.

Conservation tillage - A form of noninversion tillage that retains protective amounts of residue mulch on the surface throughout the year. Conservation tillage includes no tillage, strip tillage, stubble mulching, and other types of noninversion tillage.

Contour farming - Conducting all tillage practices along the natural contours of the land.

Dike - A levee to confine or restrict the flow of water.

Diversion - An embankment constructed across the land slope (terrace) to divert water away from active gullies, eroding slopes, buildings, or critical areas.

Erosion - Detachment and removal of soil material by the forces of water, ice, wind, and gravity.

Fathometer - A device used to measure water depth.

Land adequately protected - Land with an erosion level low enough to allow for the long-term survival of the soil resource.

Land needing protection - Land requiring the use of conservation practices to reduce erosion to a level which will allow for the long-term survival of the soil resource.

Land treatment - Soil conservation practices designed to prevent erosion or enhance the land resource.

No-till, slot, or zero tillage - Seedbed preparation and planting completed in one operation. The only area disturbed is the planted seed row. A protective cover of crop residue is left on 90 percent of the surface to control erosion.

Residue and annual cover - The practice of leaving crop residues on the soil surface or the use of annual cover crops to control erosion.

Sand - Soil particles between 0.05 and 2.0 millimeters in diameter.

Sediment - Mineral or organic soil material which has been transported from its original location to another location by the action of wind, water, ice, or gravity.

Sediment density - The ratio of the weight of a given unit of sediment to its volume.

Silt - Soil particles between 0.002 and 0.05 millimeter in diameter.

Sod in rotation - The use of a sod crop in the cropping rotation to control erosion.

Spud - A grooved steel rod used to sample layers of sediment.

Strip-cropping - The practice of growing alternating types of crops in strips to control erosion. Contour strip-cropping is the alignment of these strips along the contour of the land.

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SEDIMENT AND EROSION WORK..(U) GREAT RIVER
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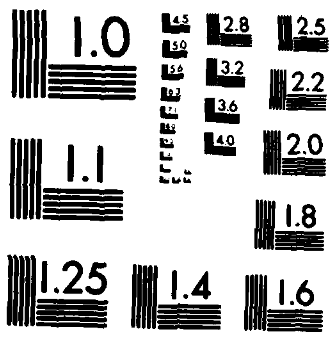

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Strip tillage - Seedbed preparation usually completed with a rotary type tiller, which mixes the residue and soil in the area to be planted. Tillage is limited to approximately one-third of the total row area. The untilled area (two-thirds) is left with a protective cover of crop residues to control erosion. Planting and tillage are usually one operation.

Terrace - An embankment constructed across the slope of the land. It is designed to interrupt the flow of water down the slope, thereby reducing erosion.

Till plant - Seedbed preparation and planting completed in one operation. The surface soils and residues are pushed from the old crop row into the row middles. Actual tillage only covers about one-third of the area. The remaining two-thirds of the surface area is covered with a protective cover of residue and loose soil.

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ATTACHMENT A

CORRESPONDENCE

ON

DRAFT SEDIMENT AND EROSION WORK GROUP APPENDIX

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WE CAN'T ALL LIVE UPSTREAM
CCMI
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July 3, 1979

Gary LePage, Chairman
Sediment & Erosion Control Work Group
Great Environmental Action Team
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Dear Gary,

I had an opportunity to visit with both Jerry Hytry and Bill Rose in Madison on June 22, at which time I expressed my disappointment in their lack of cooperation with your work group in formulating the final appendix. Bill said he would call you the following Monday.

Having taken the time to review the May draft of the SEWG appendix and, despite my knowing the lateness of the hour, I would like to make the following comments.

We are pleased that the Wisconsin Conservation Districts have shown a positive interest, and that you have used the term "conservation tillage" rather than "no-till" in the new SEWG draft appendix.

The revised draft is greatly improved. It is well organized and written in a language that most people can understand; however, I still sense a lack of urgency and strong enough statements that will prompt Congress to give sediment and erosion control a top priority. We know how SCS funds have been limited for personnel, for travel, for RC&D projects, etc. In fact, our Congressman Al Baldus says SCS is not getting any more funds now than they received in the early '30's; thus, in view of the higher salaries and increased costs, the budget is not sufficient to get the field work done. It seems to us that this GREAT Report should provide the stimuli to get the monies necessary to make things roll.

The report very adequately provides proof of some of the existing problems and the possible cures, but it still is not likely to provoke immediate, positive action.

The significance of the maps to be included, such as the loss of aquatic habitat and Lake Pepin sedimentation, is now more adequately interpreted for the reader.

There is a question in my mind as to whether the report should infer that remedies are so cost-prohibitive. Who are we to judge? The time may well come when our soils will have to be preserved and our waters cleaned up, regardless of escalated costs.

As far as the experimental streambank projects on the Chippewa are concerned, we still maintain that the results are not apt to be applicable to many of the streams that carry silt and sand to the River. We are also disappointed that all streams that carry a bed-load to Lake Pepin are not identified, such as the Rush River, the Trimbelle River, Isabelle Creek, as well as dry runs such as at Maiden Rock. These streams may not have as much effect on the River as do the Chippewa, the Cannon or the Zumbro; but in that a whole chapter was included on Lake Pepin, the report should be more inclusive, especially when the contour maps show the results of their sedimentation effects. As I said at your meeting, recommendations must be made to document all the stretches of these tributaries that need streambank stabilization. We should recommend that demonstration projects be implemented on other streams besides the Chippewa. There may be other remedies that are less costly than rip-rapping. We know people on the Wisconsin River who have actually curtailed the loss of their property using old tires.

We believe the statement about the delta at the confluence of Bogus Creek and Lost Creek should be left in the report. The watershed developments above are operating effectively, but the lower stream-banks are sorely in need of stabilization. Deer Lake continues to fill in and the muck still comes down to Bogus Point. We could show you a productive cornfield in the floodplain there, with topsoil brought down by Bogus Creek.

We were quite impressed with the contour maps of Lake Pepin, but you no doubt had adequate reason for omitting them from the new draft.

I have written for a copy of the Water Quality Work Group's appendix because your description of the sediment in Lake Pepin is not complete. The eutrophication is not mentioned, even though the EPA National Eutrophication Survey Report (1975) indicates that Lake Pepin has 11 times more phosphorus than it should have, according the the Vollen-weider scale. The sources of phosphorus should be identified in some report. Lake Pepin is fouled with dead, stinking algae and the foam is unreal.

We agree that, except for periods of high flow, most organic material from the Twin Cities may be oxidized before it reaches Lake Pepin; but the fact remains that industrial wastes, such as PCB's, heavy metals and other toxic substances, are carried by small soil particles and do settle out in the lake, only to be re-suspended by the tow-boats. The overtone of the SEWG report tends to belittle the metro contamination of the water and the sediment. We maintain that it is a significant factor, and this was proved by expert testimony given at the 7 weeks of hearings we participated in during 1977. The least you could do would be to strike out the word may (3rd line from the bottom of the paragraph pertaining to metropolitan wastes).

For some reason, Chapter II on Lake Onalaska is not included in the new draft. Surely that current data should not be omitted. Perhaps it is included in some other appendix now.

Chapter VI, "Erosion & Land Treatment," has a negative overtone and leaves one with the feeling of hopelessness because of the cost analysis. Ed still maintains that past studies prove that benefits of proper land treatment exceed the costs. It would be well to add an explanation of the benefits other than curbing sedimentation that are derived from proper land-use practices, and not take it for granted that everyone knows what they are. Perhaps this is also the place to suggest that enforceable laws should be enacted to prohibit the destruction of shelter belts, planting row crops next to streams, cash-cropping on sloping terrains, further clearing of hillsides, over-grazing, and other malpractices.

Current land treatment practices are indeed inadequate to reduce sedimentation, but the tone of this report shakes my basic philosophy that the program must be accelerated. Every farm should have an acceptable land-use plan, and SCS should have sufficient personnel to make certain such plans are implemented. I suspect that the Conservation Needs Inventory is inaccurate, because it records lands for which conservation plans were once made, but with constant change of ownership, no one knows if they are being used and the personnel is inadequate to find out. We should be asking outright for the funds to get men back into the field and sell the program. Congress should be made aware of the reasons why the SCS program is slowed down. Soul scientists, engineers, agronomists, foresters and farm planners can't get the job done sitting behind a desk all wound up in red tape. This may be the reason why so many employees feel thwarted, or should I say defeated, because they can't get out and do what should be done.

Furthermore, somewhere in this report, we should suggest to Congress that farmers be given better cost-sharing incentives to encourage more proper land-use practices, and recommend perhaps, that subsidies should be denied land-owners who do not comply.

Ed and I do not understand why you put so much emphasis on the cost of maintenance. Granted, dams deteriorate and fill up with silt that must be removed, but as far as strip-cropping and terracing are concerned, the maintenance is negligibe.

Gary, I intend the above, sketchy comments to be constructive. The report was sent to me to be reviewed, and I have been frank and candid, as usual, in stating some of my feelings. You need not take the time to answer this letter, but do please send me a copy of the final draft.

Sincerely,

Dorothy

Dorothy D. Hill
President

DDH:jak
cc: Jerry Hytry
Dan McGuiness

STATE OF WISCONSIN
BOARD OF
SOIL AND WATER CONSERVATION DISTRICTS

May 21, 1979

Mr. Gary S. LePage, Chairman
Sediment and Erosion Work Group
GREAT I
U. S. Soil Conservation Service
316 North Robter Street, Room 200
St. Paul, MN 55101

Dear Mr. LePage:

We have noted with much interest the conclusions of your work group, and especially your recommendations regarding upland erosion control.

Soil and water conservation districts (SWCD) in the major sediment source areas in western Wisconsin would appreciate an opportunity to cooperate with the Corps of Engineers, and other appropriate agencies, in a special effort to achieve an 80% level of land adequately protected against soil erosion in identified special problem areas. This Board stands ready to assist the districts in such an effort in several ways.

I would infer from your conclusions and recommendations that the Corps would be well advised to provide funds for a special program to reduce soil erosion in major sediment source areas, as a cost-effective means of reducing channel dredging costs and some of the adverse environmental consequences of excessive upland erosion to the backwater lakes. We note that the individual soil and water conservation districts, and this Board as well, are authorized to receive and administer grants of funds from federal sources, including the Corps. Moreover, the SWCDs have signed memoranda of understanding with the Corps of Engineers which would provide the basis for such a cooperative effort.

Your second recommendation, regarding a research and demonstration program for no-till farming, is also of considerable interest to us and to some of our associates in the University of Wisconsin, College of Agriculture and Life Sciences. However, I would strongly urge that a broader concept known as "conservation tillage" be considered. This allows for much greater flexibility and freedom of choice in bringing the principles of erosion control through tillage techniques into harmony with an individual farmer's operational needs. Non-inverting tillage systems based on some form of the chisel plow appear much more promising for Wisconsin conditions than do no-till systems. However, in specific cases the best solution depends on a number of factors, and the array of questions associated with no-till, minimum tillage, or reduced tillage farming certainly deserve thoroughgoing research.

Obviously there is wide interest in tillage systems which will permit use of the runoff and erosion control benefits of rough, residue covered cropland surfaces. I am certain that my colleagues in the University of Wisconsin would be interested in participating in tillage research and demonstration projects.

The problem of sedimentation in the backwater lakes seems to say to me that "you can't fool Mother Nature". I assume these lakes, as they presently exist, are largely creatures of the dam building program. I wonder what upper limit must be placed on sedimentation rates in those lakes, and whether that low a rate could be achieved, practically. And I wonder whether we have created a hydraulic regime, with our flood controlling dams and navigational locks, that is simply not compatible with indefinite maintenance of those backwater lakes. Perhaps the situation is not nearly as grim as it seem to me, from my very limited knowledge base. The upper Mississippi River Valley scene that I see on my mental A.D. 2500 videoscreen is not very pretty.

Sincerely,

Leonard C. Johnson

Leonard C. Johnson
Research and Development Director

LCJ/sv
cc: Eugene Savage
Leo Walsh
Art Peterson

END

FILMED

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DTIC